New Scientist

WEEKLY 22 June 2024

WHY OUR SOLAR SYSTEM MAY BE BIGGER THAN WE THOUGHT

RUSSIA FACES HUGE CLIMATE BILL FOR UKRAINE WAR

HOW TO SPOT A BROKEN ALIEN WARP DRIVE

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An evidence-based guide to the risks of screen time – and how to overcome them

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Do your research

Christopher Ward

christopherward.com

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Road to resilience

Hear psychologist Camilla Nord uncover how our brain constructs our sense of mental health as an intricate, self-regulating process. She will discuss how this can sometimes lead to mental illness and how the science of exercise, psychedelics and psychotherapy can help find paths to resilience and recovery. Find out more at New Scientist Live on 13 October at London's ExCeL Centre.

newscientist.com/nslmag

Tour

Human origins in south-west England

Immerse yourself in the early human periods of the Neolithic, Bronze Age and Iron Age on this gentle walking tour. Join Emily H. Wilson, former editor-in-chief of *New Scientist*, as you explore hillforts and ancient stone circles, including Stonehenge, Old Sarum, Avebury and Maiden Castle. This five-day tour starts on 15 July and costs £1845.

newscientist.com/tours

Podcast

Weekly

The team revisit an interstellar crash that left Earth exposed to the radiation outside the sun's protection, and discuss the impossible maths of the game *New Super Mario Bros*. There is also an interview with author Naomi Klein, who is the inaugural winner of the Women's prize for Non-Fiction for her book *Doppelganger,* which uncovers the online conspiracies and fictions that plague our lives.

newscientist.com/nspod

TRAVELLINGLIGHT/ALAMY

Explore Stonehenge Visit this extraordinary prehistoric stone circle

GUSTI AYU ISMAYANTI

Warning light How are habitat loss and pestcides affecting fireflies?

Video

Bringing back the light

Many people in Bali, Indonesia, consider fireflies a guiding light for lost souls. The insects are also relied on as bioindicators, a key sign of a healthy natural ecosystem, because of their sensitivity to pollution. Bring Back the Light is a firefly conservation lab in the heart of the jungle that is helping revive the declining firefly population.

youtube.com/newscientist

Newsletter

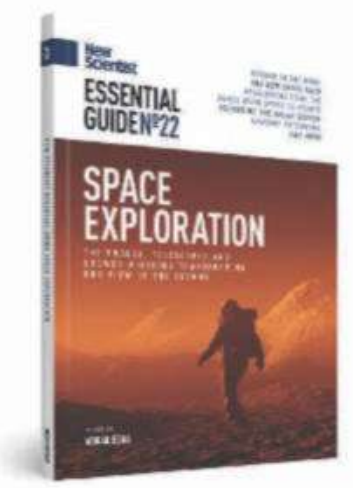
Stroke treatment

While the medical care given straight after someone has had a stroke has been improving, longer-term care has largely stayed the same for decades. That might be about to change, however, thanks to a growing understanding of the brain's ability to rewire itself in response to changing circumstances.

newscientist.com/healthcheck

Podcast

"It is like an ancient weather report for the universe: cloudy with a chance of collisions"



Essential guide

What drives us to explore space? Are we returning to the moon for the wrong reasons? How are space probes rewriting our origin story? Discover the history and future of exploration beyond Earth in this *New Scientist Essential Guide*, now available to read in the app or buy in print from our online shop.

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Smart solutions

Phased introductions to cellphones and social media would help kids more than bans

"Get phones out of schools." "Social media is toxic for teenagers." Messages like these are flying around the globe and seem to have reached a zenith of late. In the UK, concern over harms from social media and screen time has led to the Smartphone Free Childhood campaign and a government crackdown on smartphone use in schools. Ministers are even considering banning the sale of smartphones to under-16s. Meanwhile, in the US, Surgeon General Vivek Murthy this week called for cigarette-style warning labels on social media platforms.

More than 40 per cent of US children have a smartphone by the age of 10, and the concern is that excess screen use can lead to health problems, including obesity, sleep disturbances, depression and anxiety.

Some studies certainly demonstrate this link. However, as we explain in our feature on page 31, the evidence of widespread harms to children from screen time isn't as strong or clear-cut as some make it out to be.

While we figure out the details, we must protect children – particularly those most vulnerable to the negative effects of smartphone use and social media. But taking it away completely is a misstep.

"You wouldn't give access to the entire internet at first, you would let them into walled gardens"

A smarter way forward would be to give children access, even from a young age, but in a controlled and considered manner.

Imagine what a smartphone utopia would look like. It would be phased – you wouldn't give kids access to the entire internet at first, you would let them into walled gardens, much like children's TV channels do.

In such a world, you would allow limited messaging with strict moderation that relaxes with age. Systems would grant parents access that decreases over time. All this would be coupled with ongoing digital literacy classes.

Smartphones, social media and screens are here to stay in our children's lives, no matter how many warning labels are put in place. Now is the time to think seriously about how to provide the tools they need to navigate the reality of growing up online. ▮

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CoLab New Scientist

How soil health collaborations are changing agriculture

Combining local knowledge with the latest sensing technology is improving soil health in the Global South, with important lessons for the North

In parts of Tanzania, soils are disappearing. A combination of climate change and socioeconomic stresses has led to soil crumbling away into nearby rivers and lakes.

Recognising the threat, one community set up an environmental committee to allow strategic decision-making for soil restoration. They worked with researchers led by Will Blake at the University of Plymouth in collaboration with the Nelson Mandela African Institution for Science and Technology, who are experimenting with a portable gamma ray sensor that can quickly assess the health of the soil. The community identified areas where the soil was severely depleted, and so excluded their cattle. With the pressure removed, the land re-greened quickly and the soil began to recover.

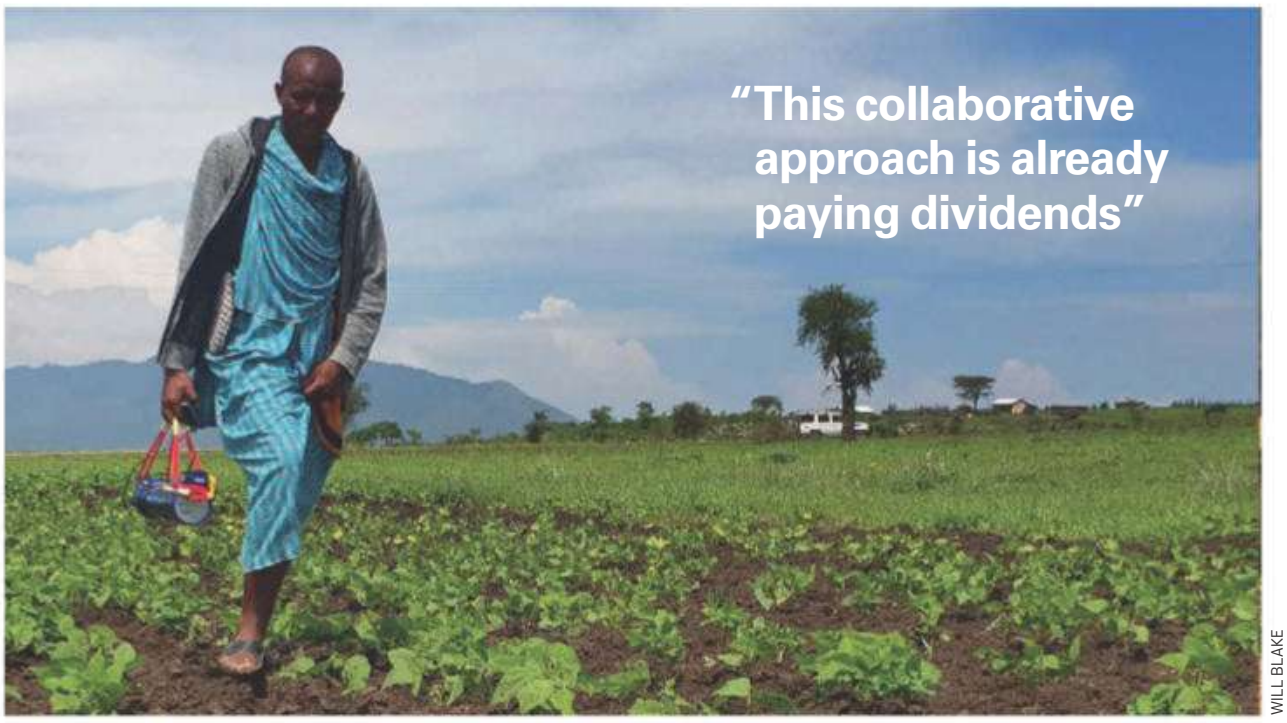
Soil health is crucial to agriculture. Unsustainable practices like heavy fertiliser use and ploughing lead to fragile soil that washes away in heavy rains – reducing the land's productivity in the long run. Further threats come from climate change, which is causing more frequent extreme weather events like droughts and heavy rains – leading to even more soil erosion. "Landscapes are starting to unravel," says Blake, "and there are consequences at large scale."

The solution is to understand the soil better, in particular, what makes it healthy and resilient, to develop more sustainable and climate-smart farming.

New sensor technologies promise to revolutionise soil health monitoring. Traditionally, this is done by taking a small number of samples for lab analysis, which only gave a smattering of data points. The newer approaches, such as gamma sensing, allow rapid surveying of fields and farms.

Blake emphasises that the technology is only half the story. "Collecting quantitative evidence through a natural science lens isn't enough," he says. Soil data has to enable farmers to devise and enact solutions and the sensor technology helps.

Scientists helicoptering in and proffering



WILL BLAKE

Farmers devise solutions using sensor data and their local knowledge of the soil

solutions doesn't work, partly because it ignores the autonomy of the farmers themselves, and partly because it neglects their extensive local environmental knowledge. Instead, Blake favours "mutual learning" in which the different groups learn from each other and talk openly.

This collaborative approach is already paying dividends. In a previous project using a different sensor, some farmers made dramatic changes. "During past seasons I used to get 4–5 bags of maize per acre using improved varieties of seeds and intensive use of fertilisers," one reported. After scanning his soils, he switched to farmyard manure and intercropping between maize and beans, in a bid to increase soil nitrogen and agriculture productivity. "Now I am getting 7–9 bags of maize in the same piece of land".

In Tanzania, researchers first assumed that soil erosion was caused by overgrazing. But when they spoke to local people, they realised the grazing decisions were actually a symptom of deeper problems, such as agro-pastoralists being pushed onto less suitable lands by population growth and other factors. Climate change is also changing rain patterns in east Africa. "The short rains sometimes just don't come," says Blake, while the long rains often come late or are "devastatingly hard". The communities are aware of all these factors.

While this pilot work has focused on the Global South, Blake says there's a lot the Global North can learn from these experiences. Many countries are moving towards regenerative agriculture, which aims to restore soils and ecosystems to make farms more resilient and sustainable. This will involve embracing many practices that are common in the Global South, but which the Global North abandoned when it adopted industrial farming. Blake says there are many "lost wisdoms" that older generations of farmers knew. "We've realized that developing the evidence base together with the communities affected is the most effective way," he says.

More at: tinyurl.com/4wddafwb

News

Clearing up
Ukraine uses AI to manage Russian landmines **p7**

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Australian pterosaur had huge tongue to gulp down prey **p14**

Early giants
Universe's first stars may have formed very fast **p16**

MATTHEW DOMINICK/NASA

Space

Starliner soars over an aurora

This amazing photo shows Boeing's Starliner space capsule passing over a glowing green aurora that appears to emerge from the craft. The perfectly lined-up shot was snapped by NASA astronaut Matthew Dominick from the SpaceX Crew Dragon capsule, which is docked at the International Space Station along with Starliner.

Environment

Russia faces $32 billion climate bill

Ukraine plans to include an estimate of the damage caused by carbon emissions from war in its compensation claim against Russia. **Michael Le Page** reports

THE first two years of Russia's war on Ukraine will result in greenhouse gas emissions equivalent to around 175 million tonnes of carbon dioxide, a group of climate experts has estimated.

The warming that will result from such emissions will lead to extreme weather around the world with impacts amounting to $32 billion, according to their research.

Ukraine intends to add these climate-related costs to the list of damages for which it says Russia is responsible, and for which compensation will be demanded.

"It will be an essential plank in the reparations case we are building against Russia," said Ruslan Strilets, Ukraine's minister of environmental protection and natural resources, in a statement.

"These are the damages that are going to happen to the economy and to societies as a result of extreme weather impacts from climate change, which are a result of emissions," says Lennard de Klerk, a businessperson involved in climate-related enterprises and the founder of the Initiative on Greenhouse Gas Accounting of War.

On 12 June, that group released its fourth assessment of the impact of the war, covering February 2022 to February 2024. The reconstruction of bombed buildings, roads and other infrastructure is the single largest source of emissions, it found, accounting for nearly a third of the 175 megatonnes (see chart, below). Its figure includes reconstruction that has yet to occur. Another 29 per cent is a direct result of warfare, with fuel use being the biggest part of this.

CENG SHOU YI/NURPHOTO/SHUTTERSTOCK

Reconstructing bombed buildings in Ukraine is a big source of emissions

About 14 per cent of the total is due to passenger airlines having to reroute flights to avoid Russia and Ukraine. For instance, those from Tokyo to London now go over Canada rather than Russia, increasing time in the air from 11 to 15 hours.

Around 13 per cent is down to the increase in landscape fires, as recorded by satellites. This isn't just due to weapons causing fires, but also to the ending of fire management in occupied areas, the assessment says.

"This will be an essential plank in the reparations case we are building against Russia"

There are large uncertainties in the figures, as there are no official numbers to rely on in most cases. Instead, the group has to turn to the likes of open-source assessments or figures from previous conflicts.

There is also the question of how far to go in assessing the knock-on effects of the war. "We try to be as comprehensive as possible," says de Klerk. "At the same time, there are limitations, some effects maybe that are too distant or too difficult to quantify."

Where will the money go?

Estimating how much harm will result from additional emissions – known as the social cost of carbon – is another tricky area. "The science on trying to put a monetary value on those future damages is still evolving," says de Klerk.

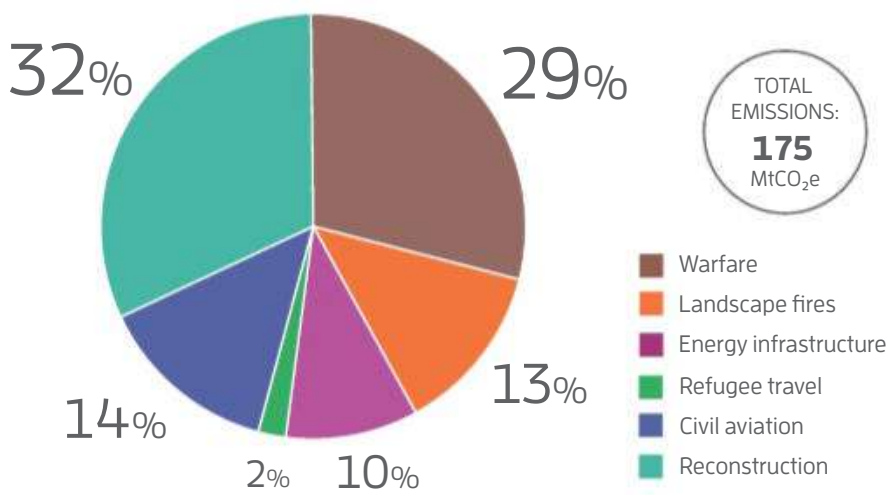
The estimate of $32 billion is based on a 2022 study that put the social cost of carbon at around $185 per tonne of CO_2.

Should this sum – which is rising daily – ever be paid, de Klerk thinks some should go to Ukraine to be used for measures such as restoring forests, to help recapture some of the carbon. Another slice should go to the countries being hit hardest by global heating, he says, perhaps via an existing system called the Green Climate Fund. But where the money would go is a political decision that remains to be resolved.

For decades, low-income and island nations have fought to establish the principle that high-emitting, high-income countries should pay for the losses and damages caused by their greenhouse gas emissions. A loss-and-damage fund was finally set up last year as part of international climate agreements. ▮

The climate toll of a war

Some 175 million tonnes of carbon dioxide emissions have been generated by the war in Ukraine in the two years since Russia's full-scale invasion, coming from six main sectors



Warfare

Ukraine is using AI to manage the removal of Russian landmines

Matthew Sparkes

THE Russian invasion of Ukraine has seen so many landmines deployed across the country that clearing them would take 700 years. To make the task more manageable, Ukrainian scientists are turning to artificial intelligence to identify regions that are a priority for de-mining, though they expect some may have to be left as a permanent "scar" on the country.

Russia's minelaying and Ukrainian efforts to remove the explosives began with the initial invasion of Crimea in 2014, which saw a few hundred square kilometres of land affected. Now, two years after Russia's wide-scale invasion, it is thought that up to 144,000 square kilometres could be mined. This is far more than could be cleared even over many generations, potentially necessitating a semi-permanent exclusion zone like the Zone Rouge created by France after the first world war.

"People get scars from war, and countries get scars from war," says Olena Pareniuk, who is working as an advisor to the Ukrainian government as part of a team developing an AI model that is already assisting in de-mining.

Weighing data

The AI model considers vast amounts of data, including tax and property ownership records, agricultural maps, data on soil fertility, logs of where bombs and shells have landed from the military and emergency services, information gleaned from satellite images and interviews with local civilians and the military. Even climate change models and data on population density from mobile phone operators could be assessed.

The AI then weighs factors such as civilian safety and potential economic benefits to determine the importance of a given piece of land and how urgent it is to make it safe.

Ihor Bezkaravainyi, a deputy minister at Ukraine's Ministry of Economy, is leading the team, and he likens the task of de-mining during an ongoing war to designing and building a submarine entirely underwater, except that the water is on fire. "It's a big problem," he says.

700
years would be needed to clear all the mines in Ukraine

144k
square kilometres of the country could contain mines

For example, says Bezkaravainyi, since agriculture is necessary for keeping Ukraine's population fed as well as supporting the country's finances – Ukraine is a major food exporter – it might make sense to prioritise agricultural land. But the problem isn't so simple, he says.

Mines and shells can leave contamination with heavy metals and pollutants that takes time to clear, and explosions can wipe away the fertile upper layers of soil and spread sand from beneath, ruining the ability to grow crops in the short term. The AI uses satellite images to detect craters and take these contamination and fertility factors into account, not only finding agricultural land that needs restoration but also calculating how hard and lengthy those efforts will be, prioritising land that can be put back to crops the quickest.

Clearing a path

New Scientist was provided with a photo of one crater (bottom image), taken somewhere in Ukraine, caused by a shell that hit a farm's store of volatile ammonium nitrate fertiliser. Bezkaravainyi says that the 40-metre-wide, 20-metre-deep crater is now a "future lake" rather than a field.

Once key areas are identified, the location is handed over to de-mining engineers who can conduct more intensive drone surveys at a rate of 3 hectares (7 acres) per hour. Quadcopters fitted with ground-penetrating radar and magnetometers are already finding some mines, although others are plastic and trickier to locate, and tall vegetation like corn or sunflowers can also affect accuracy.

Military demands on the de-mining engineers make the problem even more complex. While restoring land for future use, the same engineers must create mine-free corridors to allow troops to push forward, while further back from the front lines, engineers deliberately leave areas mined as a buffer. The AI suggestions will only ever be an approximation, says Pareniuk.

"There is no time to sit and try and solve all of the problems," she says. "We have to construct something, plan it and troubleshoot it at the same time." ▮

MAXYM MARUSENKO/NURPHOTO VIA GETTY IMAGES

HANDOUT

Above: A drone looks for mines in the Zhytomyr region of Ukraine

Left: A 40-metre-wide crater caused by a shell hitting a Ukrainian farm's store of ammonium nitrate fertiliser

Astrophysics

Did tiny black holes fill the cosmos?

Spotting mini black holes with a property called colour charge could help unravel dark-matter mystery

Leah Crane

THE universe may have once been speckled with tiny, "colourful" black holes. These exotic objects, if they existed, would have formed in the instants after the big bang and evaporated just as quickly, but they could have upset the balance of elements in the early universe.

The minuscule black holes that may have formed right at the start of the cosmos are known as primordial black holes. They are nearly impossible to detect because of their size, making them a potential candidate to explain dark matter, the mysterious substance that makes up nearly 70 per cent of the universe but has yet to be directly observed.

"If they are to account for dark matter, gobs and gobs of black holes must have formed at a very specific time in the early universe," says David Kaiser at the Massachusetts Institute of Technology. He and Elba Alonso-Monsalve, also at MIT, analysed how primordial black holes with a trait known as colour charge could have formed in the early universe's soup of particles.

Colour charge is a feature of fundamental particles called quarks and gluons. As with electrical charge, different colour charges attract one another to form charge-neutral objects.

"These black holes most likely evaporate in a fraction of a second, leaving no trace"

Unlike electricity, however, there are three charges: red, green and blue.

"They're not really colours. If we zoomed in with a microscope, we wouldn't see colours with our eyes, but it's a way of accounting for the fact that nature seems to only allow colour-neutral combinations," says Kaiser. Protons, for example, are made up of one quark of each colour, so have no net colour charge.

Today, there are no quarks or gluons floating solo – everything has combined to create colour-neutral particles. But in the first hundred-thousandth of a second after the big bang, quarks and gluons of similar colour charges gathered together in patches. Kaiser and Alonso-Monsalve found that this is when primordial black holes may have formed.

The patches of similarly charged quarks and gluons were large enough that some of the small black holes would only have access to one type of charge as they swallowed up nearby matter, so they would have become colour-charged themselves (*Physical Review Letters*, doi.org/m34t).

"This is the first realistic mechanism for black holes to form in our universe with any kind of charge," says Alonso-Monsalve. "[And] if primordial black holes formed, then these little guys would have formed too."

Even if these black holes did exist, we may never be able to find proof. "It would be very difficult to find observational signatures of these black holes because they most likely evaporate in a tiny fraction of a second, leaving no trace," says Juan García-Bellido at the Autonomous University of Madrid in Spain. "I wouldn't say the traces are subtle – they're even less than that."

But the researchers say colour-charged black holes might have resisted evaporating for up to a second after the big bang because of the crowded, hot conditions in the early universe.

If this is the case, they could have shifted the balance of the elements that began to form seconds later. And if we had powerful enough instruments to measure such a slight shift, it could be the first proof of an exotic new type of black hole and a hint as to the true nature of dark matter. ▮

Health

Varying your stride length may help you burn more calories

WALKING with variable strides uses more energy than taking consistently sized steps, which suggests it may help to burn more calories.

Adam Grimmitt and his colleagues at the University of Massachusetts Amherst recruited 18 adults, aged between 18 and 45, and told them to walk as normal for 5 minutes on a treadmill while a motion capture system recorded their average stride length.

Next, the researchers manipulated the participants' strides during another 5-minute walk by lighting up the treadmill at the positions where they wanted each person to step. Sometimes this was the same as their average stride length and sometimes it was shorter or longer by 5 or 10 per cent.

A mouthpiece measured the participants' production of carbon dioxide, which rises during exercise. For every 1 per cent increase in step variability, there was a 0.7 per cent rise in the metabolic cost of walking, defined as the energy expended by the body to move a certain distance (bioRxiv, doi.org/m34v).

The team didn't measure the calories the participants burned. But Grimmitt says: "I think it would be fair to assume that more frequent and larger variations in stride length would increase your metabolic rate while walking."

ARMAN ZHENIKEYEV/GETTY IMAGES

Taking a combination of short and long steps makes your body use more energy

When people have to work to maintain their stability from a short step to a long step, or vice versa, it can increase muscular contraction and then metabolic cost, the researchers say in their paper.

The results may also be relevant to older people, particularly those with a neurological condition, as they tend to walk with more stride variability, they write.

Jason Franz at the University of North Carolina at Chapel Hill says a link between gait length variability and metabolic cost has been shown before, but illuminating the treadmill was an innovative approach. ▮

Sara Novak

Health

Malaria drug shows promise in polycystic ovary syndrome

Clare Wilson

A MEDICINE called artemisinin already used to treat malaria could also work as a treatment for polycystic ovary syndrome (PCOS).

While the root cause of PCOS is unclear, it involves imbalances in several hormones, including too much testosterone being made by the ovaries. This can lead to irregular menstrual cycles and infertility, as well as acne and excess body hair, among other symptoms.

Those affected also tend to be less sensitive to the sugar-regulating hormone insulin, which leads to weight gain, worsening the hormone imbalances.

PCOS symptoms tend to be treated individually. For instance, laser treatments may be given to remove body hair or the contraceptive pill given to regularise menstruation.

Qi-Qun Tang at Fudan University in Shanghai, China, and his colleagues noticed that artemisinin reduced symptoms in mice with a condition similar to PCOS, so they decided to give artemisinin to 19 women with PCOS for three months.

The drug regime lowered levels of testosterone in all of them, and most also saw a decrease in another substance called anti-Müllerian hormone, which has been linked to PCOS. For 12 of the participants, the drug led to regular menstrual cycles.

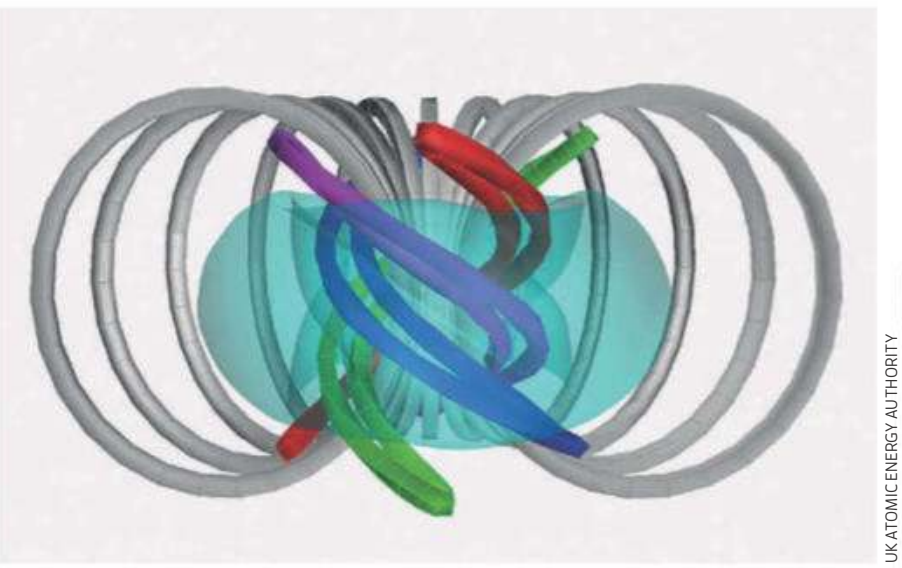
In other work in mice and in human cells, the team found that artemisinin seems to reduce testosterone production in the ovaries (*Science*, doi.org/m34w).

Stephen Franks at Imperial College London says artemisinin could act by improving insulin sensitivity, as losing weight tends to reduce PCOS symptoms, although the 19 women had a healthy body mass index on average. "If the results are as good in a randomised trial as in this preliminary study, it's exciting," he says. ▮

Technology

Hybrid design could improve nuclear fusion reactors

Alex Wilkins



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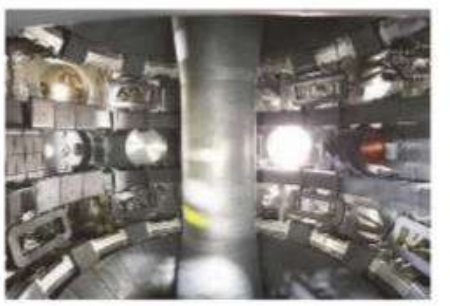


UK ATOMIC ENERGY AUTHORITY

A hybrid reactor (left) would have "banana coils" inside a doughnut-like tokamak. Below: The spherical tokamak of the Joint European Torus in the UK

MIXING up two popular nuclear fusion reactor designs could lead to more efficient power plants.

Magnetic confinement fusion reactors use magnetic fields to squeeze a cloud of charged ions, called a plasma, into a tiny volume, which increases the chances of atoms fusing together and releasing energy.

There are two main types of reactor and these confine the plasma in different ways. A tokamak, which is the design used by the recently retired Joint European Torus in the UK, is shaped like a doughnut, with coils of electromagnets wrapped around it.

The other design is used in stellarators, which are more popular for smaller, modular fusion designs, and instead use a series of twisted and bending coils to confine their plasma.

Both designs have drawbacks: the plasma inside tokamaks is prone to sudden bouts of turbulence called instabilities, which can damage the reactor or disrupt the fusion process, while stellarators can only contain a relatively small amount of plasma and are complex to build.

Now, Sophia Henneberg and Gabriel Plunk at the Max Planck Institute for Plasma Physics in Greifswald, Germany, have combined both designs to create a tokamak-stellarator hybrid.

They say it would be simpler to build and could form larger, more stable plasmas than either type of reactor alone, while also reducing the amount of energy needed to run.

The design looks similar to the doughnut shape of a tokamak, except for additional twisted electromagnetic loops running through its centre, which Henneberg and Plunk call "banana coils" (see illustration, above). From their simulations, they found that this creates enough "twisting" in the magnetic fields to avoid the catastrophic instabilities found in pure tokamaks (*Physical Review Research*, doi.org/m34x).

"It is a great example of creative theory that could have a big impact on fusion energy"

The coils also solve another engineering difficulty with tokamaks, says Henneberg, which is the need for a large current moving through the plasma itself to help confine it. The lack of a current both simplifies the design and could save energy, she says.

"This is really interesting work that uses modern theoretical and computational tools to investigate a new idea in fusion energy," says Benjamin Dudson at Lawrence Livermore National Laboratory in California. "It's a conceptual design, so quite far from something that could be built yet, but it's a great example of creative theory that could have a big impact on fusion energy if it leads to new designs and experiments."

Because of the similarity of the design to a tokamak, it might be possible to convert existing tokamak reactors to this new design, says Jorrit Lion at Proxima Fusion, a stellarator-based start-up in Germany.

Henneberg and Plunk say they are in talks with several universities to try to build one. "We cannot 100 per cent predict with the computational tools we have if you get disruptions or not, so I believe, in the end, we have to build something to check to be sure," says Henneberg. ▮

Analysis UK election

How can the next government get climate goals on track?

The UK's journey to net zero has stalled – whoever wins the 4 July election will need to get it moving again, but many climate scientists are frustrated with what the main parties are offering, finds **Madeleine Cuff**

MORE than 400 climate scientists from UK institutions published an open letter last week, pleading with the UK's political parties to pledge stronger climate action over the next parliament, ahead of the 4 July general election.

Their demands include a "credible" carbon-cutting strategy for the country, amid an election campaign that has seen little in-depth discussion of the UK's net-zero transition.

Why are the scientists worried? After all, the UK has one of the most ambitious climate targets in the world – a legally binding goal to achieve net-zero emissions by 2050 – and has halved its greenhouse gas emissions since 1990.

But the UK's race to net zero has slowed to a crawl in recent years, with annual emissions falling at half the rate required to meet interim targets.

Although big progress has been made in decarbonising the electricity supply, with zero-carbon sources now generating about half of all power, other sectors are lagging behind. Outside the electricity sector, the rate of emissions cuts must quadruple over the next seven years if the UK is to meet its promise to reduce emissions by 68 per cent by 2030, the UK government's climate advisers, the Climate Change Committee, said in October. It warned that the UK is "unlikely" to get there under current plans.

"We just simply haven't seen the level of response required," says Emily Shuckburgh at the University of Cambridge, an organiser of the scientists' letter.

Slow progress means problems have mounted for the next government to tackle.

By the end of the decade, emissions from surface transport – that is road, rail and ships – need to fall by almost 4 million tonnes of carbon dioxide-equivalent, quadruple the rate of the previous decade. Electric car sales may be growing, but those of electric vans and trucks are failing to keep up and the number of public charge points isn't growing fast enough to keep pace with the volume of electric vehicles hitting the roads. Meanwhile, the use of public transport fell sharply during the covid-19 pandemic and hasn't returned to its previous levels.

UK PARLIAMENT/FLICKR

Not so green: more action on climate will be needed in the UK's House of Commons

Big car problem

Getting the transport sector to net zero will require more than just convincing everyone to buy an electric car, says Michael Pollitt at the University of Cambridge. Fewer and smaller cars are a key part of the puzzle, he says. "If we can get people moving in radically smaller vehicles or in mass transit, that is the way that we are going to get to net zero in transport."

When it comes to buildings, home heating is the major headache. About 23 million homes in the UK are heated by gas boilers. All these homes need to be warmed by zero-carbon energy sources by mid-century, with most expected to switch to heat pumps.

But the transition is going too slowly. In 2022, just 69,000 heat pumps were installed in UK homes, far short of the 600,000 installations per year targeted by 2028. Part of the problem is financial: heat pumps cost more to install than a gas boiler and often cost more to run. "Unless the price of heat pumps comes down substantially, that is a major roadblock to decarbonising heating," says Pollitt.

These problems need solving urgently, says Nick Eyre at the University of Oxford, who signed the open letter. Gas boilers installed in 2035 will still be heating homes in 2050. "Heat pumps and vehicles, we will need to have pretty much cracked by the early 2040s. That means being very serious about it in the 2030s," he says.

That is why inaction this decade, when the UK government should be focusing on getting industries ready for mass deployment, is so worrying. "We know what to do," says Eyre. "But the last couple of years, in particular, have been a period where there's not really been any action at all."

Even tougher choices lie ahead. Emissions from agriculture and land use, for example, have barely changed in a decade, but need to fall 29 per cent by 2035. Delivering these cuts is likely to involve action to change people's diets. Likewise, cutting aviation emissions will require action to control demand, such as a tax on frequent fliers.

"The biggest challenge will be starting to impose policies and regulations which affect people's day-to-day lives," says Leo Mercer at the London School of Economics. "If policies aren't communicated well, people push back pretty strongly."

Alongside domestic challenges, the UK's slowing progress on its national climate agenda, alongside cuts to international aid and climate diplomacy, has weakened its global reputation. UK government decisions to approve new domestic fossil fuel projects, while urging low-income countries to "transition away" from fossil fuels, has also caused ire.

> **"If you don't have a positive vision yourself, you can't sell that to the rest of the population"**

Without countries like the UK demonstrating that net zero is achievable and desirable, convincing low-income countries to cut emissions is an uphill battle. So, it is crucial for the UK to re-establish its reputation as a climate leader, says Caterina Brandmayr at Imperial College London.

Next year, countries are due to submit new commitments to

reduce their greenhouse gas emissions by 2035 under the Paris Agreement. "This, therefore, is a pivotal moment for the global community," she says. "This parliament will be crucial not only to ensure delivery in the UK, but also to raise ambition globally."

Climate pledges

So, will any party deliver the scale of action needed to put the UK back on track? All the major parties agree on the need to reach net zero by mid-century. And there is strong agreement between Labour and the Conservatives on the need for more renewable power, particularly offshore wind.

Labour, however, has the eye-catching promise to deliver a fully decarbonised grid by 2030. Adam Bell at UK consultancy Stonehaven, and a former senior energy official in the UK government, says this goal is "very, very ambitious", and will push the civil service to the limits. "On power, it's difficult to find a way in which [Labour] could possibly be more ambitious."

But for Eyre, a manifesto that is credible on climate should also have ambitious aims in areas where the UK is seriously off track: on home energy efficiency, heat pump deployment, industrial emissions, land use, solar power and electric vans. "We need to do all of them," he says.

Privately, many experts doubt that any of the major parties have a policy programme with the pace and scale needed to deliver net zero by 2050. In its absence, looking for enthusiasm for the challenge ahead might be the next best sign of a party's credibility. "If you don't have a positive vision yourself," says Eyre, "you can't sell that to the rest of the population." ▮

Health

Astronaut medical records reveal the toll of space travel

Clare Wilson

MORE light could be shed on how space flight affects astronauts' health after the creation of the first "space-omics" biobank – a collection of thousands of blood and tissue samples, plus medical information, taken over multiple missions.

These include trips to the International Space Station, as well as the first all-civilian space flight, SpaceX's Inspiration4, which took four non-government-trained astronauts into orbit for three days in 2021.

Called the Space Omics and Medical Atlas (SOMA), the resource contains detailed medical data, such as on DNA damage and changes in people's gene activity and immune system functioning, collectively known as biomarkers.

Space flight is known to pose certain health risks. For instance, astronauts lose bone density and muscle mass due to the lack of gravity, and higher levels of radiation in space seem to cause cell and DNA damage, which have a range of impacts on the body.

These effects may be why astronauts are more prone to developing heart disease in later life and some have experienced worsening vision after being in space.

Collecting astronauts' medical data in a consistent way via the SOMA biobank will help researchers understand more about these changes and potentially develop ways to mitigate them, says Christopher Mason at Weill Cornell Medicine in New York, who helped put the biobank together.

"Biomarkers don't always translate into anything that's clinically meaningful, but it's a nice way to start to understand how this unique environment is impacting us," says Damian Bailey at the University of South Wales in the UK, who wasn't involved in the work.

One insight from the Inspiration4 mission is that, despite the astronauts experiencing a host of biomarker changes, most measurements returned to normal within a few months of them coming back to Earth (*Nature*, doi.org/m3t4).

This suggests that sending civilians into space doesn't pose more health risks than sending professional astronauts, says Mason. "Instead of people training for decades to go, we could start to really open up space towards more and more people."

The results from Inspiration4, which was crewed by two men and two women, also suggest that the changes in gene activity returned to normal faster in the women. That may be because their bodies have to be able to cope with a potential pregnancy, says Mason. "Being able to tolerate large changes in physiology and fluid dynamics may be great for being able to manage pregnancy, but also manage the stress of space flight," he says.

"Most biomarkers returned to normal a few months after astronauts came back to Earth"

Timothy Etheridge at the University of Exeter in the UK says it will be helpful for researchers around the world to have a common resource they can use. "You need to have a consistent approach to collecting samples," he says.

Thomas Smith at King's College London says understanding the health impacts of space flight will become more important if longer missions happen, such as journeys to Mars. "Anything that leads to extended-duration missions, it's more important to know what's going on and, ideally, address it," he says. ▮

Astronaut David Wolf at work outside the International Space Station

NASA

Health

CRISPR lung treatment offers hope for cystic fibrosis

Christa Lesté-Lasserre

A LUNG-targeted CRISPR gene-editing therapy has the potential to offer an effective, long-lasting treatment for cystic fibrosis after overcoming a major challenge.

The approach has been successfully used to edit DNA in hard-to-reach lung stem cells in mice, with modifications that endured for at least 22 months – essentially the animals' entire lives, says Daniel Siegwart at the University of Texas Southwestern Medical Center.

"I was falling out of my chair with amazement after seeing a few months of persistence," he says. "This is exciting news for potential treatment of a variety of lung ailments."

CAVALLINI JAMES/BSIP SA/ALAMY

MRI image of the damage cystic fibrosis can cause to lungs (yellow)

Cystic fibrosis is caused by genetic mutations that lead to sticky mucus building up in the lungs and digestive system. Scientists have previously developed gene-editing technologies to modify the DNA in the faulty lung cells. But getting the therapeutic agents into those cells is a challenge due to the mucus and other defences that have evolved to keep pathogens out of the lungs, says Siegwart.

A possible solution is to deliver the molecular tools for gene editing through the blood, packaged in lipid nanoparticles that slip past immune barriers. Similar nanoparticles have already been used in more than a billion mRNA covid-19 vaccines, and other teams have delivered gene therapy into people's livers in this way.

However, lipid nanoparticles naturally end up in the liver, says Siegwart. So, a few years ago, he and his team tweaked these agents to make them specifically target the lungs.

In the latest study, Siegwart and his colleagues injected 8-week-old mice with lung-targeting lipid nanoparticles carrying CRISPR gene-editing components, together with a marker that enabled the researchers to identify gene-edited cells. Over the next 22 months, they regularly analysed the animals' lung tissue and found the marker throughout the mice's lungs every time.

The results were surprising, says Siegwart, because individual lung cells usually live for only three weeks at most. Because the treatment affects the stem cells, which continually divide and produce new cells, the gene editing appears to form a replenishing pool of edited mature cells.

50%

Proportion of lung stem cells with cystic fibrosis mutation in mice corrected after 10 days

The researchers then ran tests using cells taken from people with cystic fibrosis who have a specific genetic mutation. They found that the gene-editing system embedded in the nanoparticle corrected the mutation in those cells.

Finally, they injected their treatment into the veins of mice that had been genetically modified to have that same cystic fibrosis mutation. Within 10 days, the treatment had corrected the mutation in 50 per cent of the animals' lung stem cells (*Science*, doi.org/m3vf).

"The fact that they can reach these stem cells at very high efficiency via delivery of their lung-targeted lipid nanoparticles to the bloodstream of mice is very impressive – and a first in the gene therapy field for genetic lung diseases," says Marianne Carlon at KU Leuven in Belgium.

If approved for human trials, the therapy would be administered to adults and would target the lung cells only, says Siegwart. If effective, people with cystic fibrosis "could expect lung function similar to healthy adults", he says. "Genome correction has the potential to generate years or perhaps a lifetime of benefit." ▮

Technology

Smart fabric could keep you cool in city heat

James Dinneen

CITY dwellers could soon beat the heat with clothes made using a high-tech cooling fabric.

The textile, mainly made of plastic and silver nanowires, is designed to stay cool in urban settings by taking advantage of a principle known as radiative cooling – the natural process by which objects radiate heat into space.

When it is warmed up, the material selectively radiates heat within the narrow band of infrared wavelengths that can escape Earth's atmosphere. At the same time, it blocks the sun's radiation and infrared radiation emitted by surrounding structures.

Po-Chun Hsu at the University of Chicago in Illinois and his team designed their three-layer material to "try to block more than half of [the radiation] from the buildings and the ground", he says.

The inner layer is made of a common clothing fabric like wool or cotton and the middle layer consists of silver nanowires that reflect most radiation. The top layer is made of a plastic material called polymethylpentene, which doesn't absorb or reflect most wavelengths, but emits a narrow band of infrared radiation.

In outdoor tests, the textile stayed 8.9°C (16°F) cooler than a regular silk fabric and 2.3°C (4.1°F) cooler than a material that emitted heat across a broad range. When tested on skin, the textile was 1.8°C (3.2°F) cooler than a cotton fabric (*Science*, doi.org/m3vn).

Hsu says this small difference in temperature might increase the time someone could comfortably be exposed to heat by up to a third.

"Making this stuff practical as a textile is always difficult," says Aaswath Raman at the University of California, Los Angeles. Other materials with similar properties could also be used on the vertical surfaces of buildings, he says. ▮

Mathematics

Mamma mia, it's impossible Mario!

Even a supercomputer couldn't calculate whether some *Super Mario* levels can be beaten

Matthew Sparkes

FIGURING out whether certain levels in the *Super Mario Bros* series of video games can be completed before you play them is mathematically impossible, even if you had several years to spare and the world's most powerful supercomputer to hand.

"We don't know how to prove that a game is fun, we don't know what that means mathematically, but we can prove that it's hard and that maybe gives some insight into why it's fun," says Erik Demaine at the Massachusetts Institute of Technology. "I like to think of hard as a proxy for fun."

"Can you get to the finish? There is no algorithm that can answer that question in a finite amount of time"

For their work, Demaine and his colleagues use tools from the field of computational complexity – the study of how difficult and time-consuming various problems are to solve algorithmically. They have previously proven that figuring out whether it is possible to complete certain levels in *Mario* games is a task that belongs to a group of problems known as NP-hard, where the complexity grows exponentially. This category is extremely difficult to compute for all but the smallest problems.

Now, the researchers have gone one step further by showing that, for certain levels in *Super Mario* games, answering this question is not only hard, but impossible. This is the case for several titles in the series, including *New Super Mario Bros* and *Super Mario Maker*. "You can't get any harder than this," says Demaine. "Can you get to the finish? There is no algorithm that can answer that question in a finite amount of time."

It may seem counterintuitive, but problems in this undecidable category, known as RE-complete, can't be solved by a computer, no matter how powerful, no matter how long you let it work.

Demaine concedes that a small amount of trickery was needed to make *Mario* levels fit this category. First, the research looks at custom-made levels that allowed the team to place hundreds or thousands of enemies on a single spot. To do this, the limits placed by the game publishers on the number of enemies that can be present in a level had to be removed. The team was then able to use the placement of enemies within the level to create an abstract mathematical tool called a counter machine, essentially creating a functional computer within the game.

That trick allowed the team to invoke another computational conundrum known as the halting problem, which says that, in general, there is no way to find out if a given program will ever end, or simply run forever, other than running it and seeing what happens (arXiv, doi.org/m3qt).

These layers of mathematical concepts finally allowed the team to prove that no analysis of the game level can say for sure whether it can ever be completed. "The idea is that you'll be able to solve this *Mario* level only if this particular computation will terminate, and we know that there's no way to determine that, and so there's no way to determine whether you can solve the level," says Demaine. ▮

DAVID PAUL MORRIS/BLOOMBERG VIA GETTY IMAGES

To work out if you can beat some *Super Mario Maker* levels, you need to play them

Imaging

Quantum sensor takes temperature inside a tiny worm

A QUANTUM sensor that uses tiny diamonds implanted inside a living animal could be used to study cellular processes in minute detail or detect diseases such as cancer.

The most common ways to image cells involve adding fluorescent dyes or nanoparticles and using the light these give off to map cellular processes. But these methods can fail if the markers damage the cells or change conditions, such as the acidity or thickness of cellular fluid.

Quantum sensors use the properties of quantum mechanics to detect features around them, but their precision can be limited if they are far away from their target.

Helena Knowles at the University of Cambridge and her colleagues have developed a quantum biosensing chip called Q-BiC that uses nanodiamonds to detect properties in living organisms. The nanodiamonds – each about 100 nanometres wide – are injected into the cells being studied and the chip is placed nearby to detect the state of the diamonds.

The team used Q-BiC to measure the temperature and magnetic resonance inside live cancer cells and nematode worms, and the process caused no damage (arXiv, doi.org/m3qv).

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY/ALAMY

A nematode worm viewed with an electron microscope

"The challenge was realising the diamond quantum sensing system on a chip that is both small enough to fit it into a microscope and provides a stable environment for the living sample we're imaging," says Knowles.

The chip measures diamonds that have had some carbon atoms removed and others replaced with nitrogen, which changes the quantum states that the atoms' electrons can have. After the electrons are excited with microwave radiation, they relax to quantum states that are affected by their environment, such as temperature or the local magnetic field, which can then be used to map the cell.

The researchers hope the technique will be useful for characterising diseased cells, such as cancerous ones, or for monitoring cells over long periods of time. ▮

Alex Wilkins

Extraterrestrial life

How to spot a stricken alien ship

If alien craft are using warp drives, we should be able to detect them when they malfunction

Matthew Sparkes

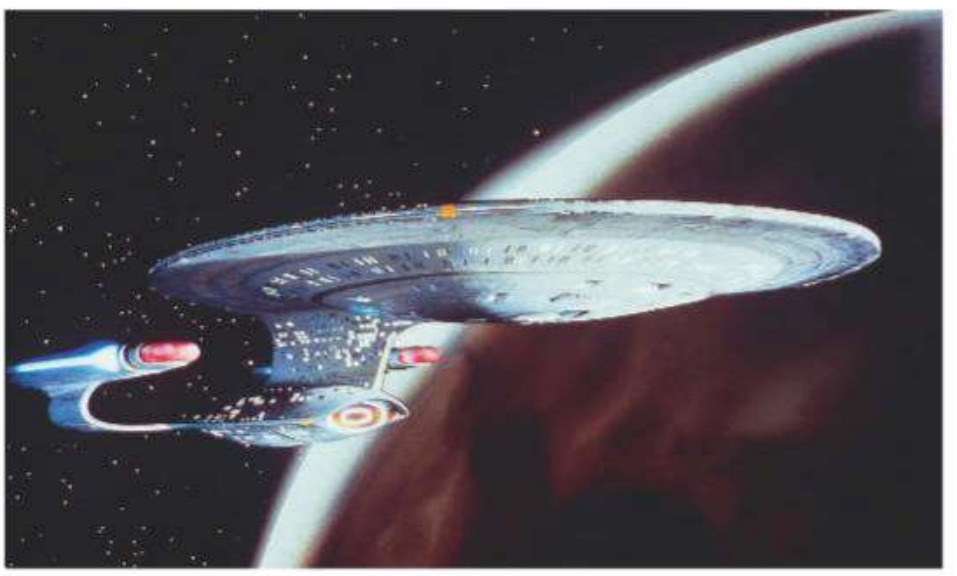
THERE is no evidence that aliens are flying around the galaxy in starships powered by faster-than-light warp drives – but if they were, we could detect such a ship breaking down using current technology, say researchers. Such a discovery could confirm the existence of alien life, although sadly any crew aboard the ship would be torn apart by forces similar to a black hole.

While warp drives are best known from *Star Trek*, theoretical physicists say it should be possible to create a bubble of space-time that can propel a craft within it even faster than the speed of light, because it is space-time itself that is moving. These theoretical warp drives rely on exotic materials that we don't know actually exist, such as ones with negative energy density, but that doesn't mean they aren't possible.

Inspired by the many warp drive mishaps depicted in *Star Trek*, Katy Clough at Queen Mary University of London and her colleagues decided to investigate whether such an incident in the real universe would release ripples in space-time called gravitational waves and, if so, whether we could detect them. They found that once a warp-powered starship was up to speed and travelling at a constant velocity, it wouldn't create any gravitational waves, but it would if it accelerated or malfunctioned (arXiv, doi.org/m3qp).

Clough says we already have the technology to detect these gravitational waves. The Laser Interferometer Gravitational-Wave Observatory (LIGO), designed to reveal secrets of the galaxy and black holes, is sensitive enough but observes the wrong gravitational wave frequency. Developing a device to look at the right frequency for warp drive signatures would be a "matter of funding" and not engineering or science, says Clough.

Like the Starship Enterprise, alien craft could theoretically have warp drives



EVERETT COLLECTION INC/ALAMY

She speculates that if we were to see evidence of warp drive problems, it could indicate that aliens were working on the technology and were having early development problems leading to failures. But one thing is certain: it would be bad news for anyone near the device at the time.

"All of this curvature in the space-time that is in the warp bubble collapses inwards before it goes out again. And that basically means you'd have really strong tidal forces. In the same way, when you fall into a black hole, you get kind of pulled apart," says Clough. "It would be a very unpleasant place to be."

Rhett Allain at Southeastern Louisiana University says current gravitational wave detectors on Earth are affected by large passing vehicles and ocean tides. Because of this, they need vast infrastructure to help offset that interference. "If you can have money to build whatever kind of gravitational wave detector you want, I'd put it in space," says Allain. "You wouldn't have to worry about all the structure that you have to build around it [on Earth]. You just have to have these devices and set them at some point in space where they can stay in the same position." ▮

Palaeontology

Australian pterosaur had a huge tongue to help gulp down prey

A 100-MILLION-year-old fossil pterosaur found in Australia may have had the largest and most muscular tongue of all its relatives.

The fossil was discovered in 2021 by Kevin Petersen, the curator at the Kronosaurus Korner museum in Queensland.

With pterosaurs – flying reptiles that inhabited Earth at the same time as dinosaurs – you normally might find one bone, says Petersen. "But as I started to dig around, more and more bone started to show." Nearly a quarter of the skeleton has now been recovered, making it the most complete pterosaur ever found by scientists in Australia.

The entire lower jaw was preserved, along with part of the upper jaw, vertebrae, ribs, and leg and feet bones. However, most surprising was the preservation of the delicate throat bones, just a few millimetres in diameter.

A team led by Adele Pentland at Curtin University in Perth realised the fossil belonged to a new genus and species in the Anhangueria family of pterosaurs. The creature is estimated to have had a wingspan of 4.6 metres. In honour of Petersen, it has been named *Haliskia peterseni* (*Scientific Reports*, doi.org/m3qr).

Although unrelated to birds, it would have looked a bit like a giant pelican, says Petersen. But Pentland says it would have been a "demon pelican" because it had a mouth full of spiky teeth.

"It would have been like a 'demon pelican' because it had a mouth full of spiky teeth"

What sets *H. peterseni* apart from any other known pterosaur is that its throat bones are much larger, indicating that it had a massive, muscular tongue, says Pentland.

The team thinks the tongue was used to catch and hold prey, probably slippery animals like squid and fish. Once prey was grabbed by its jaws, *H. peterseni*'s teeth would have closed like a cage, preventing escape, says Pentland. Like a pelican, it probably swallowed its prey whole, she says. The tongue was also probably used to push the meal down into its throat. ▮

James Woodford

Technology

Liquid crystals could improve quantum communications

Karmela Padavic-Callaghan

CREATING quantum light just became easier thanks to liquid crystals like the ones found in television screens.

Light with quantum properties will be crucial for many future technologies. Entangled light particles – or photons – could help produce quantum communications networks to support an unhackable internet or quantum imaging techniques for biomedicine.

Usually, researchers hit crystals with lasers to make them emit quantum light. A crystal's structure determines the properties of the light it emits, which then determines how it can be used. So, to change these properties, you need to redo the experiment with a new crystal, which is costly and time-consuming.

Now, Vitaliy Sultanov at the Max Planck Institute for the Science of Light in Germany and his colleagues have devised a way to create quantum light using a liquid crystal, a substance made of rod-shaped molecules that can both slosh around like a liquid and assume special arrangements like a more conventional crystal.

By exposing a liquid crystal to electric fields, they could adjust its structure and the properties of the quantum light it emitted when shot with lasers. "In this regard, liquid crystal is the perfect material," says Sultanov.

The team found the liquid crystal was much more tuneable than a solid one and nearly as efficient at producing entangled photons of light (*Nature*, doi.org/m3qn).

"These advances could be transformational in terms of applications in [quantum] imaging, communication and sensing," says Miles Padgett at the University of Glasgow, UK.

Liquid crystals could make it easier to transmit information through multiple channels at once, says the team. ▮

Health

Muscle zapping during exercise helps people recover from stroke

Clare Wilson

ZELJKOSANTRAC/GETTY IMAGES

Assisted activity is often used as a way to try to improve limb function

A NEW kind of rehabilitation therapy for people who have had a stroke, using electrical stimulation of muscles while they exercise, has helped improve their arm function.

The small trial tested a treatment that involves triggering muscles to contract as people try to move their limbs voluntarily. This seems to encourage nerve pathways to regrow in the brain.

"Physiotherapy is the only option we have for helping people recover limb [function]," says Clare Jonas at UK charity the Stroke Association, who wasn't involved in the work. "Anything that helps people recover more thoroughly would be brilliant."

A stroke happens when blood flow to part of the brain is disrupted, usually because of a blood clot or burst blood vessel, which causes nerve cells to die. Depending on the area affected, people may lose the ability to speak or to move a limb.

The usual treatment of physiotherapy exercises is thought to help forge new neural connections to bypass damaged areas, but many people still don't fully recover, says Catherine Sweeney-Reed at Otto von Guericke University in Magdeburg, Germany, who led the work.

The new approach draws on an experimental technique called functional electrical stimulation, which involves placing electrodes on the skin to stimulate nerves that normally make a muscle contract.

20

Number of people who tried out physio with electrical stimulation

However, its effectiveness in stroke rehab has mainly been tested in people whose stroke happened several months or more beforehand. The brain is thought to be better able to forge new connections between nerve cells when the stroke was recent, says Sweeney-Reed. "There's heightened plasticity, a greater readiness to re-establish connections."

Her team focused on people who had a more recent stroke. For the study, participants wore an electroencephalogram (EEG) headset that can detect brainwaves that signal the intention to move.

The system was tried on 20 people who had recently had a stroke that left them with minimal ability to move one of their arms. Half had their stroke within the past month, while the rest had it between one and six months ago.

The participants were asked to lay their affected arm flat on a table and to try to lift their hand by bending the wrist. Unaided, they could barely move it.

Some then had the stimulation timed for when they were trying to move their hand, while the rest received it at random times, to act as a control group. They all had up to five therapy sessions a week, for three to five weeks.

Among those whose stroke was most recent, getting the timed treatment improved their arm function by an average of about 20 points on a 66-point scale often used in stroke research. That compared with a three-point improvement for those in the control group.

For people who had the therapy between one and six months after their stroke, there was no significant difference between the treatment and control groups (medRxiv, doi.org/m3qk).

Jonas says the results tally with other small studies of electrical stimulation in stroke rehab. "We are now optimising how it's used," she says. ▮

Astrophysics

The universe's first stars could have formed surprisingly early

Jonathan O'Callaghan

HUGE stars thousands of times the mass of our sun could have formed in the cosmological blink of an eye, just after the big bang.

The James Webb Space Telescope (JWST) has been able to detect distant galaxies from when the universe was barely 300 million years old. Models suggest star formation could have begun even earlier in the 13.8-billion-year history of the universe, perhaps within 200 million years or less.

10,000

Early stars may have had masses this many times that of the sun

Mana Ito and Kazuyuki Omukai at Tohoku University in Japan think it could have been much earlier. By modelling star formation in the early universe, they found it might have been possible for stars up to 10,000 times the mass of our sun to have formed within 20 million years, or even just 1 million years, after the big bang (arXiv, doi.org/m3qg).

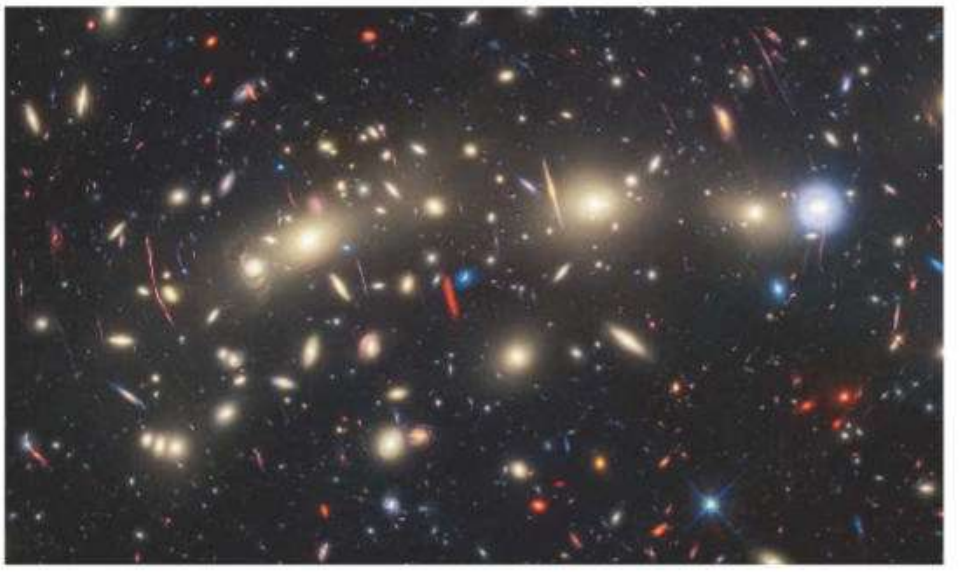
"Our model says there are more density fluctuations in the [early] universe," says Ito, meaning that matter might have more readily clumped into clouds of gas that could have collapsed into stars earlier than expected.

The first stars in our universe, known as Population III stars, were giant balls of mostly hydrogen. They have never been definitively detected, although there have been hints of them.

According to Ito, the first 20 million years of the universe would have seen higher temperatures caused by the cosmic microwave background – the remnant heat of the expansion of the universe. This would have made these stars much more massive than modern stars, because they would gather in gas more easily.

"As the accretion rate becomes larger, the stellar mass becomes larger," says Ito, forming giant stars that would have existed for just a few million years before exhausting their fuel and exploding as supernovae.

Daniel Whalen at the University of Portsmouth, UK, thinks it is unlikely that matter would have clumped enough to form stars so early. "At this point [in the universe], there are density perturbations, but none of them are enough to form stars," he says.



NASA, ESA, CSA, STSCIET AL.

Some of the most distant stars imaged by the James Webb Space Telescope

Whalen says it is possible that a rare clump of gas could have coalesced in the first 40 million years of the universe, but the chances of detecting this are slim.

JWST is probing further back into the universe than ever before, but is still limited by the amount of infrared light it can collect. Jeyhan Kartaltepe at the Rochester Institute of Technology in New York says its limit is probably about 200 million years after the big bang. "We could potentially see supernovae at earlier times," she says. "But we'd have to look in the right place at the right time."

If star formation did begin much earlier than this, we might have to wait for the next generation of telescopes to find out, says Ito. ▮

Environment

Marine fungus can digest floating plastic pollution

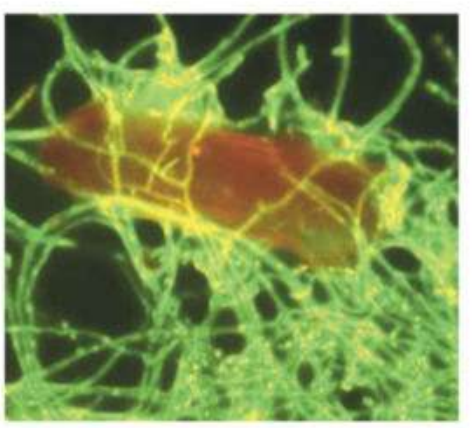
A FUNGUS found on litter floating in the North Pacific Ocean can break down the most abundant type of plastic that ends up in the sea.

In lab experiments, Annika Vaksmaa at the Royal Netherlands Institute for Sea Research and her colleagues have shown that the white, thread-like fungus can degrade one of the most pernicious plastics, polyethylene, providing the material has first been exposed to UV radiation, such as from sunlight (*Science of the Total Environment*, doi.org/m3qf).

UV radiation can induce chemical modifications in polyethylene that make it more susceptible to attack by the fungal enzymes, says Vaksmaa.

The digestion process releases carbon dioxide, but the emissions weight-for-weight are no greater than the small amount that humans release while breathing, the team found.

Vaksmaa believes that the fungus, known as *Parengyodontium album*, has great potential, but she is cautious about putting it to use in the wild. "If we take a microbe and add it to a natural system, then we may ruin it while trying to do good," she says. Instead, she suggests it may be best to gather the plastic and bring it back to land to be digested by *P. album* that has been grown in bulk. This could be done using techniques like those used in the brewing industry, she says.



ANNIKA VAKSMAA/NIOZ

A plastic particle (red) is colonised by the fungus *Parengyodontium album*

The need for UV exposure means that *P. album* won't work on plastic that sinks. But given the diversity of marine fungi, Vaksmaa thinks it probable that her team will find a deep-sea species that can do this. ▮

Adrian Barnett

mediaplanet

Supply Chains and Logistics

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Careful research and vehicle testing are necessary, assuming the new vehicles are available to buy.

Logistics sector faces infrastructure challenges in its **route to net zero**

With the industry's target to achieve net zero by 2050, the logistics sector is focused on decarbonisation of all transport modes, but the challenges this will pose cannot be overlooked.

Denise Beedell
Senior Policy Manager, Logistics UK

Business group Logistics UK, which represents the whole sector, is clear that achieving net zero is a priority and launched its own member commitment – the Route to Net Zero – in July 2021. For operators to reach decarbonisation deadlines, future governments will need to work closely with industry to overcome challenges facing our sector.

Vehicle and fuel decarbonisation challenges

Traditionally, logistics has relied on fossil fuels to move goods from A to B, but the commitment to decarbonise brings new challenges. The ongoing global shortage of microchips to power decarbonised vehicles is just one reason for delay in bringing new models to market.

However, more fundamental concerns exist concerning the lack of an efficient and effective national refuelling network and indeed, the preferred fuel to be used. Switching a fleet to a new fuel source is costly for logistics operators, which typically operate on extremely narrow margins. Careful research and vehicle testing are necessary, assuming the new vehicles are available to buy.

Some logistics operators have been quoted up to £1 million to increase power supplies at their depots.

Adapting fleets for decarbonisation

Regardless of the chosen fuel for newly decarbonised fleets, each operating model may require adaptations to ensure vehicles are ready for every shift, posing additional questions: If battery electric vehicles are to be used, is there national grid capacity to enable rapid recharging? Is there proximity to a power source, ensuring cabling can be installed quickly and efficiently?

Some logistics operators have been quoted up to £1 million to increase power supplies at their depots — a cost that will need to be passed on to customers. Public recharging opportunities across the Strategic Roads Network are also a concern, as are the practicalities of where larger vehicles can access suitable charge points and availability, which are fit for purpose for larger vehicles, and whether alternative fuels will be available for those yet to electrify.

Tackling challenges to achieve net zero

Logistics have made significant progress in decarbonisation, but challenges remain, particularly regarding costs, before an effective switch to zero-emission operation can be made. With decarbonisation, Brexit, new technology and other disruptive forces driving change in how goods move across borders and through the supply chain, logistics has never been more important to UK plc.

Logistics UK supports, shapes and stands up for safe and efficient logistics and is the only business group representing the whole industry. For more information about the organisation and its work, visit **logistics.org.uk**

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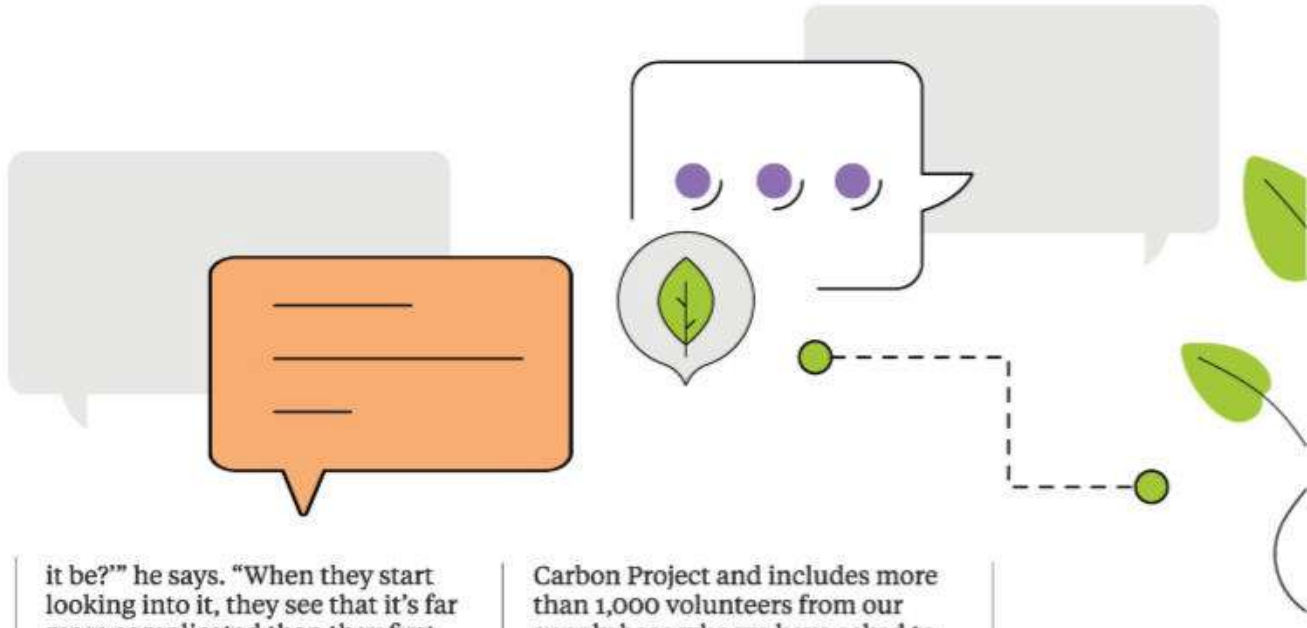
How the right all-in-one software can accelerate **supply chain decarbonisation**

Companies looking to reduce their supply chain emissions should use well-designed digital tools and software to help scale decarbonisation programmes in the most effective way.



Vishnu Nair
Head of Zeigo Activate and Zeigo Hub, Schneider Electric

SPREAD WRITTEN BY
Tony Greenway

Supply chain decarbonisation is becoming a major focus for businesses due to pressure from customers, investors and a rapidly evolving regulatory environment. Increasingly, companies need to find innovative ways to measure, track and then reduce their own carbon emissions — plus the carbon emissions created by their suppliers.

Realising the supply chain emissions challenge

Vishnu Nair is Head of Zeigo Activate and Zeigo Hub, two solutions from Schneider Electric's sustainability software brand, which aim to simplify supply chain decarbonisation. "Different companies are waking up to this challenge at different times," he admits.

"Some may be wedded to 2030 emission reduction targets and are only just realising that they have around five years left to achieve them. Then there are others that haven't woken up to the problem at all. They are going to find themselves in trouble very soon."

When sponsor companies encourage their suppliers to take part in a well-designed supply chain programme, the result can be greater collaboration that elicits a significant reduction in overall emissions. However, kickstarting such a programme is not an easy process, warns Nair. So, don't underestimate it or think that you can sort it out overnight with the aid of a spreadsheet because it's rather more involved than that.

"Some companies might be tempted to think: 'How hard can it be?'" he says. "When they start looking into it, they see that it's far more complicated than they first assumed, particularly if they want to run a large programme. Once they understand what it entails, they realise they'll need support from decarbonisation software and digital tools."

Decarbonisation software providing emissions visibility

To begin with, decarbonisation software makes it easier to communicate your programme's objectives to your supply base, providing them with learning, guidance and other content in a scalable way. It also allows your suppliers to easily provide you with all the data you need, giving you greater visibility of where emissions are created.

Without this type of solution, you would have to rely on emails, phone calls and in-person interactions with all your suppliers — and that's just not a realistic proposition, particularly if their number runs into the hundreds or even thousands.

Scalable software empowering suppliers

Well-designed software also has the power to open up your programme to a large cohort of suppliers, not just a select, more manageable few. "Take our own supply chain programme as a case in point," says Nair. "It's called the Zero Carbon Project and includes more than 1,000 volunteers from our supply base who we have asked to achieve a 50% reduction in their operational emissions by 2025.

"Now, some of these volunteers are large corporations. However, many of our small and medium-sized suppliers were looking to reduce their emissions, too, and asked to be involved — so we gave them access to our software. That's the beauty of this type of solution. It's scalable, so it can generate more data from more users, and so create a better, more meaningful impact for the supply chain owner."

Expert consultation to ensure programme success

However, even the best software won't give you the results you require if your overall programme has been badly designed. "It's entirely possible for companies to use great software within a badly designed programme and end up with poor results," agrees Nair.

"That's why we feel it's important to have an in-house or external consultant with subject matter expertise. They can look at your programme's objectives and ensure that it is properly equipped to tackle challenges such as incentivisation, reporting frequencies and interim goals. Once the initial design is right, it's the software's job to enable operational execution and scaling."

Zeigo™ by Schneider Electric

Accelerate your supply chain's decarbonisation with Zeigo

Collect data and see progress reports while giving your suppliers and network the digital tools they need to reduce their carbon footprint.

What to look for in decarbonisation software

Before choosing your decarbonisation software, it's vital to assess it properly and check that it does everything you need it to do. Is it able to collect consistently reliable, high-quality data from all your suppliers? Can it pull and push data to and from your existing software ecosystem?

Is it purpose-built to drive — and track — supplier engagement in the programme? Is the interface easy to use, both for you and your suppliers, regardless of their size or familiarity with sustainability?

Can it deliver valuable carbon emissions education and training content to those who need it?

"A corporate user who is well-versed in decarbonisation may require a solution with more advanced features and workflows," explains Nair. "Whereas, at the other end of the spectrum, small and medium-sized businesses may lack sustainability expertise and resources. So, if the software can offer users support and guidance on carbon calculation — rather than just asking them for numbers — they are more likely to respond positively to it."

A solution that removes barriers and drives action

However, don't be tempted by software that only solves your data problems, warns Nair. Otherwise, it will act as nothing more than a reporting platform. Instead, adopt a long-term view and choose a holistic solution that drives your suppliers to take serious energy efficiency or renewable energy-oriented actions. After all, your real aim isn't to simply collect information from your suppliers. It's getting them to reduce their emissions.

"For example, our software provides users with guidance on setting targets for themselves," says Nair. "It can also ask them if they would like a customised decarbonisation plan, outlining specific projects that they can implement on-site; it can connect them with companies that are able to deliver those projects for them.

So, it's not just extracting information from users. It's about giving them something in return and removing barriers to action. If they feel rewarded for regularly providing you with data, they will be motivated to implement decarbonisation measures. As a result, your programme is more likely to be a success."

Benefits of using an all-in-one service provider

Be aware, too, that not all decarbonisation software is created equally. Different software has different levels of maturity. "Supply chain owners may choose a solution that looks good on paper," says Nair. "Unfortunately, as they use it, they discover it doesn't have all the features they need. They may try to solve this issue by going to another vendor — but dealing with multiple vendors only complicates the process."

There's an advantage to partnering with a company that can provide consulting, software and hardware in one vertically integrated delivery model.

That's why there's an advantage to partnering with a company that can provide consulting, software and hardware in one vertically integrated delivery model. "If you have to turn to a different vendor every time you face a new challenge, it can slow down your decarbonisation efforts," says Nair. "It's easier and faster to work with one consultancy that can help you solve every challenge you meet incrementally."

Don't fall behind on using decarbonisation software

Companies that aren't yet using decarbonisation software to power their supply chain programmes shouldn't put it off any longer, insists Nair. Time is ticking on. "My message to them is: start yesterday," he says. "My other piece of advice is: supplier engagement is everything. So, it's well worth spending extra time to ensure that the solution you choose works for you and will be met favourably by the suppliers in your programme. Ultimately, that's the best way to decarbonise your supply chain."

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To learn more about how to engage your value chain or take the first step in creating a supply chain decarbonisation programme, visit **zeigo.com/zeigo-hub**

Invest in employees to close the largest skills gap in 10 years

Candidates with knowledge about emerging processes and technologies are tough to find. By investing in employees, companies can build a better future.

Abe Eshkenazi
CEO, Association for Supply Chain Management

Three-quarters of companies around the world are reporting talent shortages. That's the highest level in a decade. However, it's not just a lack of people; it's a lack of people with the right skills. Particularly in supply chain, 64% of surveyed employers say their biggest hiring challenge is finding candidates with the right skill sets.

Factors behind the skills gap

One problem is the growing list of emerging skills companies require. Amid supply chain digitisation, employers are seeking candidates with experience with the latest data analytics and supply chain visibility software, digital twins, robots and artificial intelligence, blockchain and other supply chain technology. However, by definition, it's difficult to have experience with something new.

The skills gap will only widen

This skills gap isn't going away, either. For example, artificial intelligence and digitisation will change about 25% of jobs within the next few years. Realistically, technology continuously changes, and those who are employed or are seeking employment need to keep up.

Artificial intelligence and digitisation will change about 25% of jobs within the next few years.

Professionals are doing a good job investing in their own development. However, their educational choices do not always align with their employer's priorities. For example, individuals are focusing on technical skills, but companies say they are prioritising analytical and creative thinking skills to work with the technology.

Closing the skills gap

The answer isn't to spend resources seeking a rare candidate. Instead, organisations should invest in their current employees to upskill them to work with new processes and technologies. This can be done in-house with apprenticeships and mentoring or outsourced to professional education programmes.

Investing in your employees shows that you value their hard work and loyalty. These engaged, appreciated individuals will be the best candidates for effectively bridging the skills gap and building a better future for your organisation.

Why businesses must embrace **circular practices** in supply chain management

Supply chains have the opportunity to prepare for future global disruptions by adopting circular economy practices.

Whether it was through television, radio or a newsfeed, we have all witnessed the stories unfold around Covid-19, global conflicts and the tough economic headlines of inflation and recession over the last few years.

These significant, global 'where-were-you?' moments seem only to be increasing in frequency, and the knock-on effects are becoming more apparent in our everyday lives, whether it is through price hikes or empty shelves.

Future-proofing through circular supply chains

Business leaders are rightly seeking to future-proof their organisations against global disruptions while meeting an ever-growing demand for lower costs and increasing environmental expectations.

Supply chain professionals, responsible for sourcing and moving the 100 billion tonnes of material that enter the global economy each year, will be crucial to solving this challenge.

Traditional supply chains were configured to support linear 'take-make-waste' models. In contrast, a circular supply chain will encourage the elimination of waste, the circulation of products and materials and the regeneration of nature.

Mitigate risk and enhance sustainability

Switching to a circular supply chain and decoupling operations from natural resource consumption offers the opportunity for businesses to reduce their exposure to price volatility, increase material security and help meet environmental objectives.

'Building a Circular Supply Chain' — a recent white paper by the Ellen MacArthur Foundation — sets out the benefits and critical next steps of integrating these practices into an organisation's operations.

Leaders in this space can begin to build their circular supply chains by focusing on nine areas, including engaging with suppliers, changing business models and redesigning their supply networks.

Staying ahead with circular practices

In a world of ever-increasing shocks and challenges, it is essential that those working across global supply chains stay one step ahead of further disruptions by adopting circular economy practices and future-proofing their organisations.

Andrés Oliva Lozano
Senior Research Analyst, Ellen MacArthur Foundation

Supply chain professionals can learn more about how to adopt circular economy practices into their operations by scanning the QR code.

Views

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Simon Ings is absolutely terrified by *The Beast* p30

Comment

A win for all

From measuring longitude at sea in the 18th century to tackling antibiotic resistance today, everyone benefits when we reward ideas, says **Martin Rees**

THE Oscars. The Booker prize. The Nobels. The award ceremonies that punctuate our year are all inherently backward-looking, celebrating past achievements. But there is another type of award, one that looks to the future – a challenge prize. Such prizes don't recognise past successes, rather, they incentivise future ones.

The idea is simple: a challenge is selected – with a clear-cut target – and a jackpot is offered to whoever first reaches that goal. Examples include the Longitude prize on antimicrobial resistance (AMR), which has just awarded £8 million to Sysmex Astrego for its PA-100 AST System, a rapid diagnostic test that could transform the treatment of urinary tract infections and so help tackle the rise of AMR.

The challenge prize format has a lot to offer. By opening the field to the widest possible pool of inventors – Nobel laureates and mavericks alike – it can inspire myriad potential solutions to a problem. These prizes also raise the profile of, and have the power to solve, some of the most pressing problems of the time.

Consider the original Longitude prize, launched in 1714 to tackle the greatest scientific challenge of that century: how to effectively measure longitude at sea. Without the ability to do this, many ships lost their way and foundered, so the British government established a prize of £20,000 (several million in today's money) to reward whoever could solve the problem.

ELAINE KNOX

The challenge, overseen by the Board of Longitude, was met by John Harrison for his chronometer. This seafaring clock kept time to within 5 seconds on a rolling ship on a transatlantic voyage. This allowed sailors to determine their exact position, leading to safer shipping and opening up global trade routes.

Later, a 12,000-franc contest to find ways of preserving food for Napoleon Bonaparte's army led to the invention of tinned food, and a $25,000-prize inspired the first solo transatlantic flight, by Charles Lindbergh. More recent challenge prizes have focused on suborbital space flight, driverless cars and robotics.

Challenge Works, an enterprise from innovation charity Nesta, has since revived the format in the UK, running more than 90 prizes and distributing £156 million in funding over the past decade or so.

As someone who, in 2014, had held three of the eight posts on the original Board of Longitude – Astronomer Royal, president of the Royal Society and Cambridge professor of astronomy – it felt appropriate to commemorate the tercentenary of the Longitude prize's launch. I suggested an "anniversary" prize to address a current challenge.

A shortlist of six topics was created – each representing one of the biggest scientific challenges of our era: antibiotic resistance, dementia, green flight, sustainable food, restoring movement to those with paralysis and access to clean water. A public vote determined the final choice: to design a test that could cheaply and quickly identify if a person's disease was bacterial or viral and thereby avoid the prescription of unnecessary antibiotics – a major driver of antibiotic resistance.

In 2022, in partnership with Alzheimer's Society, Challenge Works also launched a £4 million Longitude prize on dementia, looking to incentivise the creation of artificial intelligence-based technologies that can help those living with dementia to lead more independent lives.

The Longitude prize on AMR attracted some 250 entries, so it is thrilling that now, a decade after the award was launched, Sysmex Astrego's system has won. The firm will receive millions, but it won't be the only beneficiary. If its invention improves the treatment of urinary tract infections and helps stem the rising tide of antibiotic resistance, it is society that will be an even bigger winner.

Martin Rees is chair of the Longitude prize committee and the UK Astronomer Royal

Future Chronicles

A human-fungus chimera

This week, we visit a cult in late 21st-century Japan that biologically merged with a fungal network in hope of immortality. **Rowan Hooper** tells us how it happened

Future Chronicles explores an imagined history of inventions and developments yet to come. Rowan Hooper is the podcast editor at *New Scientist* and author of *How to Spend a Trillion Dollars: The 10 global problems we can actually fix*. You can follow him on X @rowhoop

Invention
Human-fungal chimeras

Time stamp
2080s

Tag line
Live forever – but as a fungus!

PREPARE to meet members of an extreme cult that took root – literally – in a forest on a Japanese island in the 2080s. An unknown number of people traded their status as individual humans to merge biologically with the fungal network in forest soil.

The cult grew out of a Buddhist sect that modernised the traditional belief that there is no spiritual or moral boundary between selves. The concept was adapted by Zen ecologists who championed the idea of the holobiome, viewing an organism as a super-entity comprised of the host body and all its symbiotic microbes. The No Boundary sect saw no essential difference between humans and other living organisms. It was effectively the radical rebirth of the "back to nature" movement of the 19th and 20th centuries, boosted by new technology.

With advances in synthetic biology, the sect engineered a merging of living human tissue with the mycorrhizal network, the underground fungal web in soil. The new entities – for they could no longer be called human – communicate with a form of intelligence that is entirely novel: by becoming chimeric with fungal biology, they also prolonged their lives for decades, perhaps indefinitely. This aspect appealed to life-extension enthusiasts.

Communication with the fungal network was achieved when biological computers were designed that were able to mesh with microbes more naturally than conventional machines.

From the 2030s onwards, computers made from living cells found an important niche when inserted into restored ecosystems: they could measure parameters such as parasite density, and make adjustments to the system in reaction to environmental pollutants. Fungal computers comprised of mycorrhizal networks were trained in the same way neural networks are trained for artificial intelligence; they provided information about the status of natural environments and affected changes in trees far away.

These living computers played an important part in the restoration of Earth's ecosystems following the devastation of the previous centuries. One side effect was that they encouraged people to engineer closer symbiotic unions with other organisms.

"Mice and people who submitted to the chimeric process lost their ego as they merged with the fungi"

The safety of fungal-human chimeras was assured by first gene editing a suitable mycorrhizal species and testing its growth in tissue cultures, then in mouse models in the 2070s. The mice's vital signs changed as the fungus grew through their systems – their lungs and heart initially continued to supply oxygen, but before long the fungus took over this function. At that point, their ability to vocalise was lost.

The brain activity of a chimeric fungus-mouse changed to resemble that of a mammalian brain on psychedelic drugs. In particular, the default mode network – the set of brain regions that give people a sense of self and ego – was disrupted. Mice and people who submitted to the chimeric process lost their ego as they merged with the fungi. In dissolving the boundary between species, the subjects lost their self, and the No Boundary sect elevated them to the highest level of their priesthood.

Until around the 2020s, the mycorrhizal network had been largely ignored by crop breeders, but its vital importance in plant growth and carbon storage gradually became appreciated. As farming methods changed to optimise the network, the use of artificial fertiliser was massively reduced. This removed the harmful effects that nitrates had on soil microbes and river ecosystems, as well as the carbon emissions made during fertiliser production.

The No Boundary cult grew out of a desire to erase divisions, and in some sense to atone for the crimes of humanity against nature. Some fungi are effectively immortal, and since there were predicted longevity benefits to the procedure, the first to merge with fungi were older members of the sect who felt they had less to lose. Some welcomed the renunciation of their human status. Still, the procedure was a one-way trip, and it was attractive only for a minority. The base was on Yakushima, an island in the south of Japan with an ancient, largely intact forest ecosystem.

Communication with the chimeras dwindled as the fungi began to dominate after several years of integration, so we don't know what the experience was like. Before they lost the power of speech in the mid-2080s, the last words of cultists attempted to convey the vastness of the new world they were glimpsing, and awe at the transition. Many decades later, remote brain scans of people who had undergone the process suggested regions associated with memory formation, love and imagination were highly active. ▮

This column appears monthly. Up next week: Chanda Prescod-Weinstein

Editor's pick

Urgency needed now the climate alarm is ringing

1 June, p 8

From Geoff Harding, Sydney, Australia

Record-breaking temperatures in the air and oceans highlight two extremely urgent challenges.

Despite the Paris deal for a 1.5°C warming limit and undertakings at subsequent COP meetings, total energy-related annual carbon dioxide emissions continue to rise, approaching 37 gigatonnes in 2023. Drastic action to reduce our dependence on fossil fuels is needed for us to have any chance of reaching net zero by 2050.

The other challenge is adaptation to climate change, particularly the rising number of days with almost intolerable temperatures in nations near the equator. Most of these countries have released minimal emissions. The industrialised world must provide urgent financial assistance to alleviate the problems or the inevitable result will be huge numbers of climate refugees.

Hours and hours of fun thinking about time

1 June, p 32

From Paul Bowden, Nottingham, UK

Your intriguing article about retrocausality poses the question of whether quantum information could be sent back in time. Surely the answer must be yes. How else could we explain the fact that electrons sent through a double slit, one at a time, create an interference pattern on a screen beyond? Each electron must be sending a signal back through time to the previous particle, in order to let it know that it needs to interfere "with me".

From Ben MacGregor, Thurso, Caithness, UK

You report that time could be a quantum illusion. Maybe it is the other way round. Perhaps space-time is fundamental and the simplest way a universe with time can be predictable, but not deterministic, is for it to obey the rules of quantum mechanics.

We could tackle salt addiction at its source

8 June, p 32

From Talia Morris, Cape Tribulation, Queensland, Australia

Yes, there is a problem with salt addiction, but it is social rather than biological. A liking for salty food is far from universal and is probably acquired rather than innate. In family homes and in restaurants, the salt shaker is a ubiquitous presence on the table. Many people add salt to their food before they even taste it.

When I was growing up, not only did my mother cook with a fairly modest amount of salt, I was always encouraged to taste food before adding anything to it. And almost always, I was happy with it the way it was and didn't add salt. As a result, I grew up without any particular fondness for salty food.

Altering the sodium content of table salt could be good for public health, but avoiding habituation to a high-salt diet would be a better long-term solution.

The AI singularity is only nearer for wrong reasons

1 June, p 28

From Brian Reffin Smith, Berlin, Germany

Alex Wilkins's review of books on artificial intelligence mentions Ray Kurzweil's prediction that the Turing test of machine intelligence will be passed by 2029, along with his belief that the singularity – when AI will surpass human intelligence – is nigh.

I don't think this is just a question of AI's progress. Judging by our breathless espousal of much "creative" AI, we are approaching the singularity from the opposite direction too, by dumbing down in accepting a mere superficial resemblance in the work of AI to what we regard as adequate art and literature.

One could almost assert that an AI will be deemed to have reached equivalence with human general intelligence when we are stupid enough to say it has.

You can have your milk and drink it

8 June, p 44

From Christopher Jessop, Marloes, Pembrokeshire, UK

James Wong needn't choose between drinking milk or using it as a plant fertiliser. Drink the milk, then, a few hours later, you can be fertilising plants with it – possibly in a way that makes it easier for the minerals etc. to be assimilated, especially if your efflux is diluted with soft water.

Wooden buildings are the gift that keeps on giving

8 June, p 24

From Trevor Jones, Sheringham, Norfolk, UK

Graham Lawton delved into the many benefits of using wood in construction beyond its ability to store carbon, and I can vouch for some. Years ago, I designed an award-winning school using Japanese-style hybrid-timber construction, including a laminated timber frame with solid-timber decking.

The real reason for the choice of timber was for the physical, psychological and spiritual benefit to pupils and staff. The school was designed to be biophilic: biophilia literally meaning a love of life or living things. I see a great future for the use of wood in buildings.

Three meals a day is a dream for some

1 June, p 37

From Sam Edge, Ringwood, Hampshire, UK

In your interview with Sophie Attwood, it was good to read about the simplicity of effective interventions to modify our unsustainable eating habits. However, the final quote that "8 billion people are eating three meals a day" is debatable.

According to a recent UN report, close to a billion people aren't food secure. They are probably grateful if they get one good meal a day. The report estimates that 2 billion people can't afford to eat healthily. Both figures are rising not falling.

Offsetting: A chicken and egg problem

11 May, p 22

From Ben Craven, Edinburgh, UK

Even if we ignore the various technical doubts about carbon offsetting, whether offsetting a flight makes flying acceptable depends upon what activity you think of as coming first.

The usual view is that the climate-negative activity of flying is being compensated for by offsetting. But an alternative view is that the climate-positive act of offsetting is being nullified by the taking of the flight. Seen from this angle, using offsetting as a way to continue flying starts to seem like a terrible waste of our limited offsetting opportunities.

Why don't we just throw our rubbish in a volcano?

8 June, p 30

From Robin Stonor, Oxford, UK

Your review of the book *Eruption* got me wondering if it is possible to dump anything into an erupting volcano? Could, say, landfill waste be disposed of in the gaping "incinerator"? ▮

Want to get in touch?

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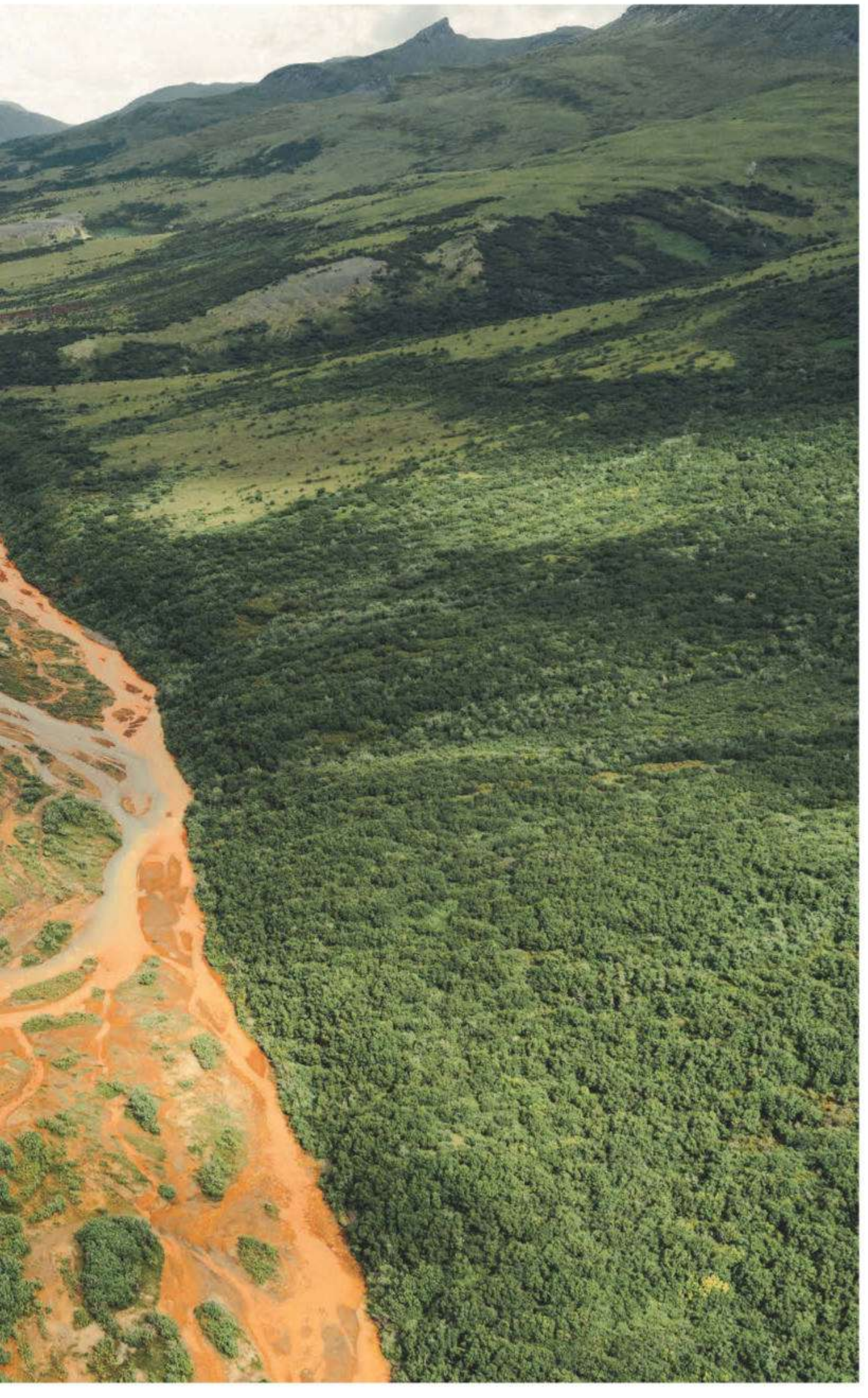
New Scientist video
Discover more about Alaska's orange rivers
youtube.com/newscientist



Rusting river

Photographer Taylor Roades
Earth Photo

LOOKING at this braided orange river bordered by lush green, you could mistake the scene for just another snapshot of a stunning river valley. But a closer inspection reveals that all is not as it seems.

Photographer Taylor Roades travelled to the remote western Brooks Range in north-west Alaska last year to draw attention to how global warming is turning these waters not just rust-coloured, but into rust itself. The colour is down to oxidised iron, which, along with sulphuric acid, is formed as sediments once trapped in the frozen permafrost are released as the ice melts. The chemicals enter nearby tributaries, creating a concoction that is toxic for ecosystems and wildlife.

This photo and the one below show how "the most remote places and ecosystems are being detrimentally affected" by human activity, says Roades. The region, which is hundreds of kilometres from any settlement, has warmed by 2.4°C on average since 2006.

Roades's shots, titled *Rust River*, have won the New Scientist Editors Award – one of nine categories in this year's Earth Photo contest, which showcases photos and videos that tell compelling stories about our planet. The winning entries will be on show at the Royal Geographical Society in London until 21 August.

Gege Li

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Inside the sustainable supply chain revolution

Supply chains are complex, many layered and hard to understand and control. But effective methods and technologies for making them sustainable are beginning to emerge

Copper, cobalt and lithium are crucial for the clean energy transition. But more than 70 per cent are under serious threat from climate disruption, according to recent research carried out by the global professional services company, PwC. The same is true for 90 per cent of the world's rice production.

That's why global companies need to factor climate and nature into their supply chain strategies and why taking action on climate change is becoming essential to future resilience and growth.

For these businesses, unsustainable practices, climate disruption and the breakdown of ecosystem services are a massive risk to operations, to reputations and to continued profitability. Governments are also imposing stricter regulations covering both environmental and social factors, and investors and customers are becoming more demanding too.

Companies that get ahead of the game can reap rewards by devising ways to make their supply chains more sustainable and more resilient against external shocks like extreme weather. This approach can also open new markets for discerning customers willing to pay higher prices for sustainably-sourced products.

None of this is easy, however. Modern supply chains are often long and hugely complex. Laptops and smartphones, for example, are constructed from components built on other components, by suppliers with their own complex supply chains, and all based on minerals sourced from mines around the world. For such a process to be sustainable, the company selling the final product needs to have oversight of their entire supply chain.

Few do. The challenge they face is to obtain better transparency, not just from their immediate suppliers, but along the entire length of the supply chain.

That's why so many companies are looking to improve supply chain sustainability. Jeremy Howard, Director of Sustainable Supply Chains at PwC UK, says that a year ago only a handful of clients wanted this: now he gets about one new enquiry per week.

Many are reacting to new regulations. The EU's Carbon Border Adjustment Mechanism, for example, effectively places a price on certain greenhouse gases emitted in the production of selected imports, and means that companies must work with their suppliers to calculate the carbon intensity of those imports. The EU also has regulations excluding products made with forced labour, and is pushing companies to do due diligence on sustainability through the Corporate Sustainability Due Diligence Directive.

In 2023, the European Union also introduced the Regulation on Deforestation-Free Products, which requires anyone selling certain commodities in the EU – such as soy, palm oil and cocoa – to demonstrate that they "do not originate from recently deforested land".

"That is a remarkable piece of legislation," says Will Evison, Director of Climate and Nature Strategy at PwC. "It requires traceability back to the parcel of land where inputs are coming from." Most commodity supply chains don't have anything of the kind. "It is a colossal challenge."

Alongside regulation, are the physical realities of the world. Environmental problems like climate change and ecosystem degradation can affect supply chains, often reducing their resilience. In April, PwC outlined the scale of the problem in its Climate risks to nine key commodities report, and the need for companies to urgently adapt their supply chains in response.

Supply chain concerns stretch beyond the environment

YURI ARCURS/PEOPLEMAGES.COM/ADOBE STOCK

The fact is that many companies have significant "nature-related dependencies", says Evison. In a 2023 analysis, PwC found that in five industries all the economic value of companies' operations was highly dependent on nature – and so could potentially be wiped out by ecosystem disruptions. In another 11 industries, at least 35 per cent of economic value was highly or moderately dependent on nature.

Regenerative farming

This threat can be mitigated if dependencies are well-managed. Many organisations and big food brands are trying to transition the agricultural parts of their supply chains towards regenerative practices. These include low-till agriculture, which causes less damage to soil structure and releases less greenhouse gas, and replaces toxic pesticides with natural pest management.

What makes a supply chain sustainable stretches beyond environmental concerns. Companies are also facing increasing pressure to address the human rights impacts of their global supply chains. PwC works with companies to identify modern slavery risks and establish effective human rights related governance and due diligence processes. A notable example is the 2022 Commonwealth Games, where PwC conducted supplier reviews internationally to provide unprecedented insight into working conditions and labour practices, allowing the Games to monitor the working conditions for workers across their supply chains.

Most companies do not currently have enough data on their immediate "tier 1" suppliers to meet incoming regulations, and that's before they tackle the trickier lower tiers that are not supplying them directly.

When it comes to decarbonisation, companies face a daunting task as Scope 3 emissions are both large and indirect, often making up 65 to 95 per cent of their total corporate footprint. "Uncertain estimates and poor data quality are causing many companies to focus much of their effort on measurement rather than implementing strategic reduction activities", says Bryan Hartlin, Net Zero Transformation Lead for PwC's Global Sustainability Impact Centre. "However, mature procurement and supply chain teams are now thinking about the significant changes they need to make to their product or portfolio strategies, processes, people and technology to really drive decarbonisation."

While perfect data might be difficult to obtain, useful actionable data is not. Leading companies are using this data to establish a baseline and to focus their efforts, including creating meaningful incentives for suppliers.

To transform on the scale needed to address regulatory, environmental and social concerns, companies are turning to technology to enable them to get insight and information about their supply chains.

"We want to make sure our supply chains are more traceable and that we know what the flow of our supply chain from raw materials looks like," says Hannah Cool, Director of ESG Transformation at PwC UK.

Technologies like cloud computing can help improve this transparency, as can access to third-party data sources. Some systems use AI to model linkages between companies based on publicly-available information. But "many small producers are not on public registers or online, so this can be only a start", says Howard.

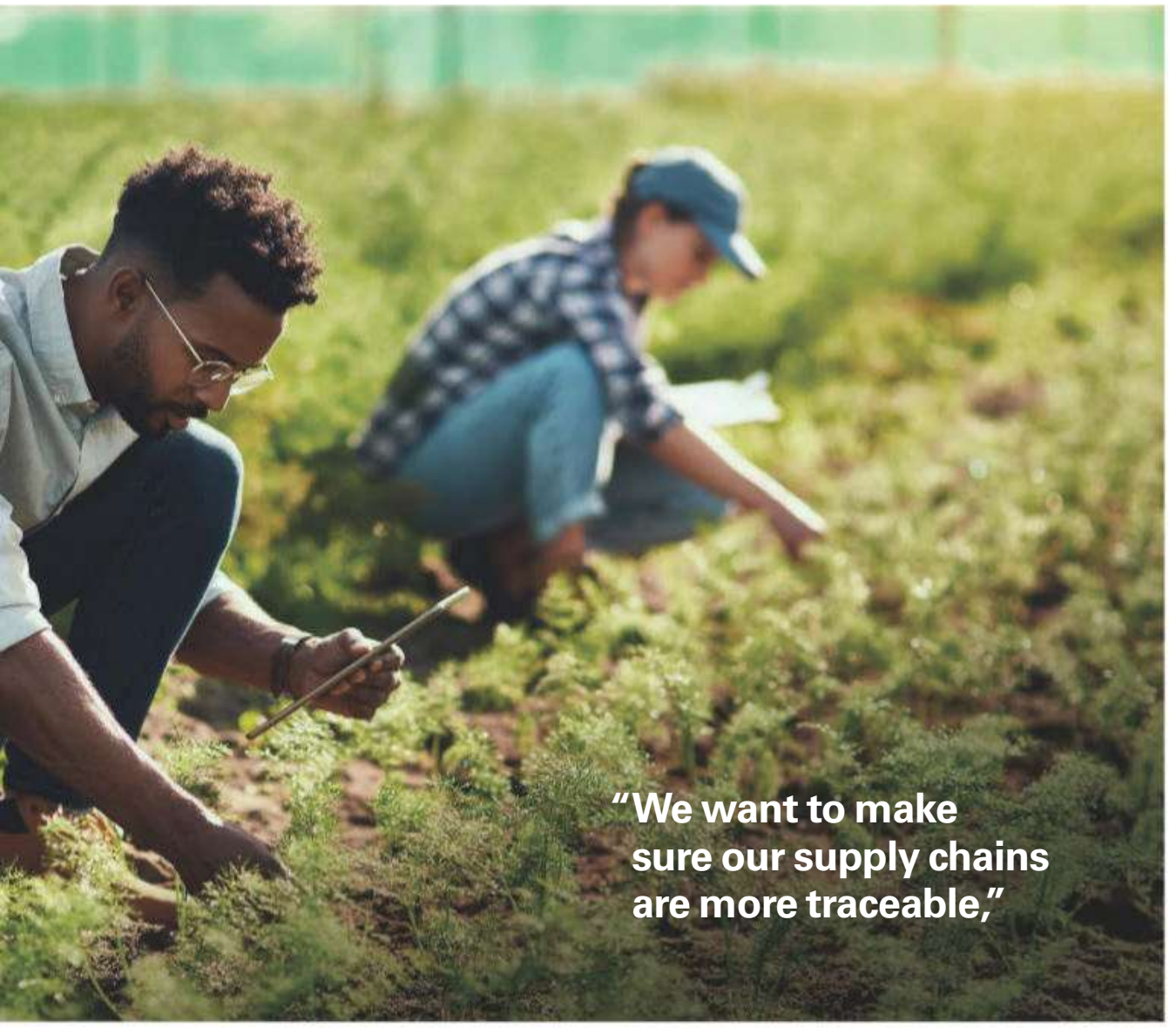
Nevertheless, once this information is gathered, it can be attached to products. "You can attach something as simple as a QR code to a shipment and you can then follow it through your supply chain," he says.

To help companies with this, PwC works with external suppliers that use technology and satellite imagery to monitor sites like mines and farms, generating essential information about producers' impacts and establishing the source of origin of commodities and materials.

There's also the global challenge of obtaining information from small- and medium-sized enterprises (SMEs), which Cool calls "the backbone of the economy". SMEs make up the majority of suppliers in many industries, but struggle to comply with complex reporting systems. It's an issue where a common standard of critical metrics for monitoring the impact and risks of supply chains, enabled by technology, could make a big difference.

Building transparent supply chains is a challenge, but the prize is much more than meeting regulatory compliance. Sustainable supply chain practices are essential to build resilience, remain competitive and thrive in today's complex and uncertain world.

More at: www.pwc.co.uk/esg



The rules of the game

From chess to nuclear war planning, **Jeremy Hsu** enjoys a wide-ranging examination of how games have shaped the world – for better or for worse

Book
Playing With Reality
Kelly Clancy
Allen Lane (UK); Riverhead (US)

GAMING is a prehistoric innovation that first came into vogue when domesticated animals and agriculture were still considered emerging technologies. Many of the most compelling and enduring games invite people to engage with simplified models of reality where they can practise reasoning and decision-making skills. Games have even inspired military strategists and economists to harness games-style thinking and simulations when trying to understand how the world works or predict the future.

Kelly Clancy's book *Playing with Reality: How games shape our world* presents a sweeping narrative about how the ancient and enduring appeal of gaming has influenced philosophers, mathematicians and scientists. But it isn't a detailed history of board games or modern video games. Instead, Clancy weaves a cautionary tale about what happens when human fascination with games translates into a belief in the power of simplified world models that are often untethered from reality. Some game-inspired ideas about human behaviour have even encouraged the world's most powerful companies and governments to implement gamified systems that are warping the reality we live in, and not necessarily for the better.

Clancy's greatest concern involves game theory: the influential maths framework that distils human complexities down into simplistic depictions of people as rational agents, often narrowly defined as selfish ones, who maximise their most preferred outcomes at the expense of other players.

Developed by mathematician and physicist John von Neumann along with economist Oskar Morgenstern, game theory has spun off many scenarios for studying self-interested human behaviour. These range from the prisoner's dilemma, in which game theory typically assumes that self-interested criminals will choose to betray one another during interrogation, to mutually assured destruction (MAD) in nuclear war planning. But Clancy cautions that game theory's "mathematical abstractions of complex scenarios" frequently fail to align with empirical evidence for how humans think and behave in real life, such as tendencies towards altruism and cooperation.

Scientists' obsession with games like Go have inspired AI breakthroughs

ROBERT PAUL VAN BEETS/ALAMY

Game theory's detachment from reality can be problematic because the "once niche mathematical discipline has imperialized many social sciences, including economics, political science, law, ethics and psychology," argues Clancy.

"Clancy worries that viewing the world through game theory colours interactions between people"

One of the most consequential game theory exercises involves expecting nuclear-armed countries to refrain from launching a first strike on their peers, lest they risk mutually assured destruction through an opponent's swift counterstrike. The MAD framework's supposed balance requires unwavering commitment to instant nuclear retaliation, which can perversely encourage aggressive nuclear brinkmanship in the name of demonstrating resolve and prime leaders to have hair-trigger reactions to potential false alarms.

Clancy's broader worry is that viewing the world through the game theory prism can colour how people interact with each other. If societies implement economic markets, systems of governance and work cultures that encourage greedy, self-interested behaviour, more people may be tempted to override their altruistic, cooperative impulses. "Originally invented to chart human behavior, game theory has since warped the territory it was intended to map," writes Clancy.

Playing With Reality also explores how computer scientists' obsession with games such as chess and Go has inspired some breakthroughs in artificial intelligence. Clancy's observations probably benefited from working at Google DeepMind, as she traces the rise of dominant game-playing machine systems such as IBM's Deep Blue and DeepMind's line of AI models, starting with AlphaGo. But she questions whether game-playing AIs can translate to more complex real-world problems beyond specialised applications such as predicting protein interactions with drugs.

It occasionally feels like Clancy's wide-ranging narrative may exaggerate the impact of games in certain cases. I suspect most historians wouldn't attribute myopic German military decision-making in the two world wars primarily to the extensive use of war games. But overall, this is a rewarding read that raises important questions about who defines the rules of the game-inspired systems that dominate modern life – and whether we should automatically accept those rules.

Putting maths on the map

A new look at how vital mathematics is to map-making is an engaging exploration of a fascinating subject, finds **Sarah Hart**

Book

Mapmatics

Paulina Rowińska

Picador (UK); Belknap Press (US, out 17 September)

LIGHTGUARD/GETTY IMAGES

MATHEMATICS helps us understand the world, and in Paulina Rowińska's *Mapmatics: How we navigate the world through numbers*, the focus is on its indispensability in the making of visual representations of that world – maps.

As a mathematician, I already knew some of the theory, but it was a pleasant surprise to find this book full of fascinating examples and facts that I didn't know, including real-world implications of ideas that might be assumed to lie squarely in the realm of the theoretical. Things like it being impossible to determine the exact length of a coastline because it keeps growing with the increasing precision of your measurements (or as Rowińska puts it, if an ant and an elephant agree to meet for a drink 300 miles along the coast, they will almost certainly not end up in the same pub).

Like most mathematicians, I was aware of this curious fractal quality of coastlines, but what I didn't know is that legislators have come up against this as a genuine problem, in managing treaties that specify distance from the coast.

The book opens by looking at the challenge presented by Carl Friedrich Gauss's *Theorema Egregium* (or Remarkable Theorem), which Rowińska explains through the medium of pizza. This wonderful piece of maths gives us a kind of Heisenberg's uncertainty principle of maps: a flat map of the spherical(ish) Earth can represent areas accurately, or distances accurately, but not both.

Maths can tell us what is possible and help us to achieve the goals of our map. There are many excellent illustrations in the book, so it may be churlish to wish for more, but it would have been helpful to see the Gall-Peters projection, which accurately shows the relative areas of continents, but distorts their shapes, alongside the Mercator projection, which does the opposite.

Rowińska does a good job with her choice of topics, which provide a gateway to many intriguing ideas and offer several entertaining diversions. When talking about distance, for example, there is a discussion of Hamming codes, which are designed to detect errors when messages are transmitted across noisy channels. This doesn't have much to do with maps, but I was willing to go along for the ride.

There were one or two curious omissions, however. Given the book's cover features contour lines, it is strange they aren't discussed, especially as the concept of isolines more generally is so powerful. I was also surprised that, though the book is strong on the inherent biases wrapped up in the historical choice of map design, there wasn't much discussion of the longitude problem or why 0° longitude ended up running through Greenwich, London.

***Mapmatics* is entertaining throughout, with illuminating examples of a huge range of maps and their uses. On top of navigation, it covers how mathematical analysis of maps showing incidence of disease or crime has been used to stop outbreaks and catch criminals, as well as the uses and abuses of maps for political ends. A bureaucratic decision over boundaries can affect everything from how much funding your child's school receives to who wins the next election. Mathematics can help detect bias in such decisions.**

The chapters are loosely grouped around themes like scale and connectedness. Each is full of interesting applications of maths to related challenges, like the use of space-filling curves to make food deliveries more efficient. The writing style is appealing – playful but with a serious message – and Rowińska clearly has a deep knowledge, both of maps and the maths behind them. An engaging look at a fascinating subject.

Sarah Hart is the professor of geometry at Gresham College in London

New Scientist *recommends*

Chelsea Whyte
US editor
New York

Lately, I have been in the mood for puzzles. Helping me scratch that itch has been a book called **S.** by Doug Dorst and J. J. Abrams. When you unbox it, you find a novel called *Ship of Theseus* by V. M. Straka, a character who we learn either disappeared or died under mysterious circumstances.

But the real story here is in the marginalia, where two readers who have taken the book out of a library try to solve the mystery. Involving flyers, postcards and a decoder ring, it takes a little practice to learn how to read this story, but it is wonderfully immersive.

SHARED MEMORY

Another puzzle I have been loving is the video game **Animal Well** (pictured above). At first, it seems simple: you navigate as a blob through a pixel-art world. But once the game is "done", there are more secrets to figure out, including some that require collaboration among players in the real world in an online forum. Weeks later, I haven't finished this one either, but I am delighted there are still puzzles to solve.

The film column

Beauty of *The Beast*

Bertrand Bonello's twist on a Henry James novella from 1903 may be the most indirect critique of technology ever made. This film is shocking, memorable – and absolutely terrifying, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

CAROLE BETHUEL

Léa Seydoux (and plenty of dolls) sets the screen on fire in *The Beast*

"Something or other lay in wait for him," wrote Henry James in 1903, "amid the twists and turns of the months and the years, like a crouching beast in the jungle." The beast in his tale was (just to spoil it for you) fear itself, for it was fear that stopped our hero from living any kind of worthwhile life.

Swap around the genders of the couple at the heart of James's *The Beast in the Jungle*, allow them to reincarnate and meet as if for the first time on three occasions – in Paris in 1910, LA in 2014 and Chengdu, China, in 2044 – and you have a rough idea of the mechanics of Bertrand Bonello's magnificent and maddening new sci-fi film.

Through a series of close-ups and red herrings, *The Beast* manages to be an utterly riveting, often terrifying film about love, the obstacles to love and our deep-seated fear of love even when it is there for the taking. It is also an epic account of how ordinary human timidity, once aggregated by technology, destroys the human race.

Léa Seydoux and George MacKay play star-crossed lovers Gabrielle Monnier and Louis Lewanski. In 1910, Gabrielle fudges the business of leaving her husband; tragedy strikes soon after. In 2014, an incel version of Louis would sooner stalk Gabrielle with a gun than try to talk to her. The consequences of their non-affair aren't pretty. In 2044, Gabrielle and Louis meet on the way to "purification" – a psychosurgical procedure that heals past-life trauma and leaves people, if not without emotion, then certainly without the need for grand passion.

"This film is about love, obstacles to love and our deep-seated fear of love even when it is there for the taking"

Somewhere in these timelines are the off-screen "events" of 2025, which convinced people to hand their governance over to machines. Why would humanity betray itself like this? The blunt answer is: because we are more in love with machines than with each other, and always have been.

In 1910, Gabrielle's husband's fortune is made from celluloid dolls. In 2014, Gabrielle and Louis collide disastrously with warped images of themselves and each other, in an uncanny valley of predatory social media and manipulated video. In 2044, dolls and puppets have become fully conscious robots. One of these even begins to fall in love with its "client" Gabrielle. Meanwhile, she, Louis and everyone else are undergoing psychosurgery to fit in with artificial intelligence's brave new world.

No version of Gabrielle or Louis is comfortable in their own skin. They take it in turns wanting to be something else, even if it means being something less. They see the best that they can be, and it pretty much literally scares the life out of them.

Given this is the point *The Beast* wants to put across, you have to admire the physical casting here. Both leads exhibit superb, machine-like self-control. Seydoux dies behind her eyes not once but many times in the course of this film; MacKay can go from trembling Adonis to store-front mannequin in about 2.1 seconds. And when full humanity is called for, each actor demonstrates extraordinary sensitivity: handy when you are trying to distinguish between 1910's unspoken passion, 2014's unspeakable passion and 2044's passionless speech.

The Beast may be the most indirect critique of technology ever made. Heaven knows how it will fare at the box office. But any fool can make us afraid of robots. This intelligent, shocking and memorable film dares to focus on us. ▮

Film
The Beast
Bertrand Bonello
In cinemas

Simon also recommends...

Book
Cloud Atlas
David Mitchell
Sceptre
David Mitchell's half-dozen artfully nested period thrillers add up to a rollicking account of humankind's relationship with technology.

Film
Until the End of the World
Wim Wenders
A long and whimsical tale spun around environmental disaster, global conspiracy, and the invention of a new kind of dreaming.

Digital damage?

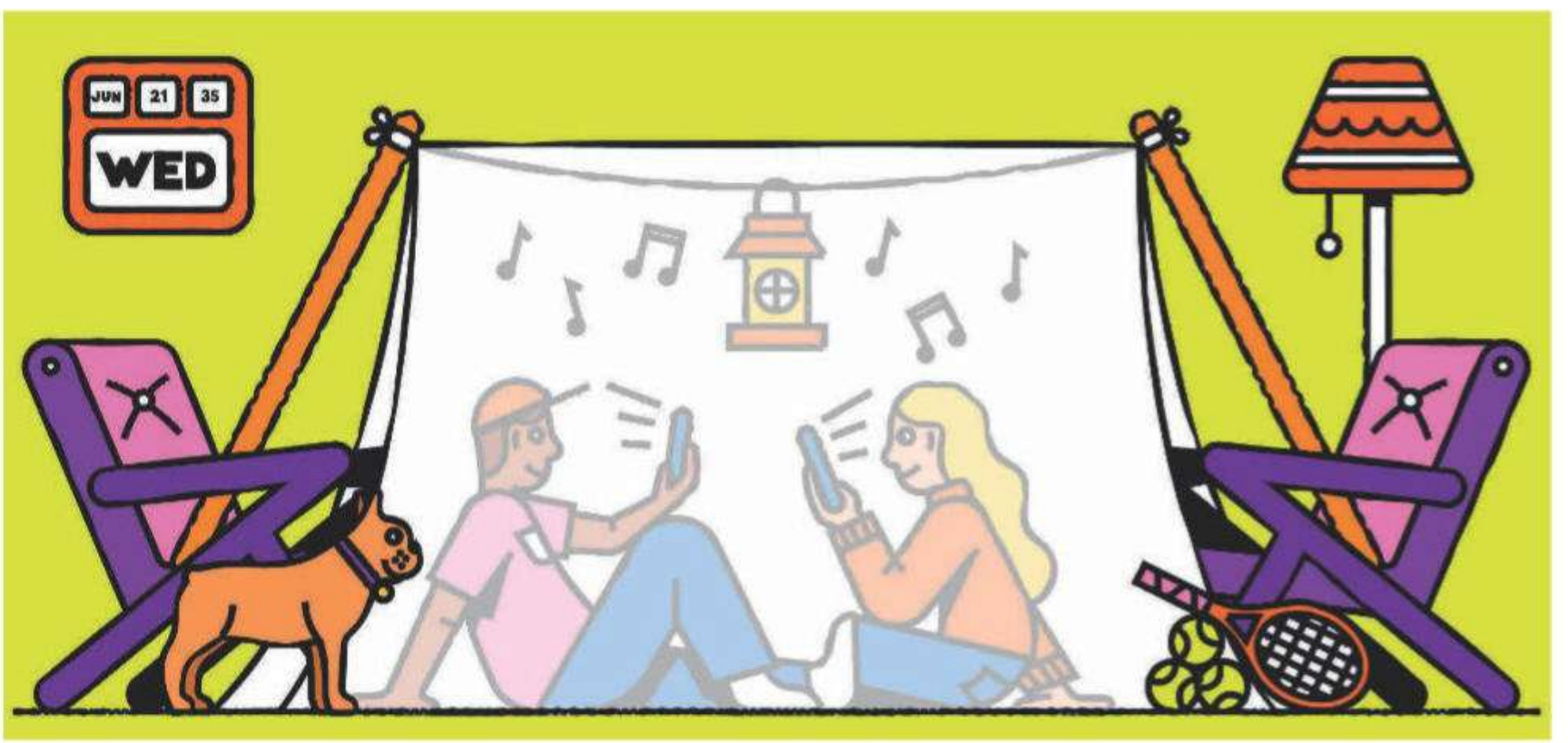
There are few more contentious issues for parents than children's screen time. What does the evidence show about its effects? **Michael Marshall** investigates

"GET off your phone!" Most parents will have found themselves yelling some version of this at their offspring – often to be met with eye-rolls.

We have all found ourselves spending more time on screens in recent years, with the rise of smartphones and social media. Children are no exception. The covid-19 pandemic also resulted in a huge rise in their screen time as a result of lockdowns and school closures.

There are a lot of scary claims about excess screen time for children and teenagers: that it is harming their mental health, leading to depression, eating disorders and even suicide, and is cutting into time they would otherwise spend socialising or exercising, causing loneliness and poor physical fitness. In short, the fear is that too much time on digital devices is ruining kids' lives – and tech companies, which have designed their apps to hook us, are complicit. No wonder governments around the world are considering curtailing screen time for under-18s.

Yet a closer look at the evidence doesn't support this overwhelmingly negative picture. This doesn't mean tech giants are benign and don't need more regulation. But it does mean we need to think more carefully about what healthy screen time for young people looks like and how best to make the online world accessible to them. So here's a guide to what we really know about the impact of screens and social media. ›



TIM ALEXANDER

One thing is clear in this complex area: children and adolescents now spend a lot of time on screens – just like the rest of us. A 2023 review that compiled research from 2016 to 2021 found that 6 to 14-year-olds worldwide spent an average of 2.8 hours a day on screens. The covid-19 pandemic drove a sharp increase because, for many young people, education shifted online, as did socialising and entertainment. One study found that even in late 2021, when lockdown restrictions had largely been lifted, total screen time was still 1.1 hours above pre-pandemic levels.

Furthermore, even the youngest children now often spend time on screens. Groups like the World Health Organization and the American Academy of Pediatrics recommend that kids under 5 should have little or no screen time, regardless of whether it relates to televisions, computers, phones or video games. Yet a 2022 review found that only a quarter of children under 2 in many different countries had no screen time, while just 36 per cent of 2 to 5-year-olds had their daily screen time limited to 1 hour a day.

One of the most popular online destinations for younger children is the gaming platform Roblox, whereas for teenagers it is social media and YouTube. In most countries, sites like Facebook and X allow users to join at 13, though using a false age to sign up is common. YouTube allows younger children, but only with parental permission.

These services are offered by vast and hugely profitable companies like Alphabet (which owns Google and YouTube), Meta (which owns Facebook, Instagram and WhatsApp) and ByteDance (which owns TikTok). The firms want you to use their apps. In particular, social media sites make money through advertising, so have devised ways to entice as many people as possible to spend as much time on them as possible. "The profit is advertising and that will shape the choices they make," says Amy Orben at the University of Cambridge.

23%

of UK children aged **8 to 12** give their age as 18+ on social media apps

SOURCE: WWW.OFCOM.ORG.UK/__DATA/ASSETS/PDF__LE/0015/245004/CHILDREN-USER-AGESCHART-PACK.PDF

But what are the costs of all this screen time for young people? This is a surprisingly difficult question to answer, especially with a paucity of long-term data. It could be that the concerns are yet another example of the techno-panics that inevitably accompany the adoption of new technologies (see "Techno-panics of the past", right).

But let's start with the case for the prosecution: that children's mental and physical health, and their overall development into well-rounded adults, is being harmed. At the forefront of this argument are Jean Twenge at San Diego State University in California, author of *iGen*, and Jonathan Haidt at New York University, who wrote *The Anxious Generation*. They argue that children are addicted to their phones, that their mental health is suffering and that urgent action is needed. They point to evidence that the mental health of children and adolescents has worsened significantly in the past two decades. In many countries, growing numbers of young people, especially teenage girls, are seeking medical help for conditions like anxiety and depression.

There can be no doubt that many youngsters are having bad experiences on their screens. In May, a UK parliament report found that 79 per cent of children in England encountered violent pornography before the age of 18 and 81 per cent of girls and women aged 7 to 21 have experienced some form of threatening or upsetting behaviour online.

One example of such behaviour is cyberbullying. A 2023 study found that a third of children in the US have experienced cyberbullying, with a Canadian study from the same year finding that girls and young people from ethnic minority groups were more likely to be victimised.

Cyberbullying is a significant contributor to teenagers being admitted to hospital for psychiatric care, according to unpublished research by Michelle Drouin at Purdue University Fort Wayne in Indiana and her colleagues. "Parents were sometimes completely unaware that their children are experiencing cyberbullying," she says. Many teens didn't let on, as they thought their parents weren't tech-savvy enough to help and would just take their phones away.

On top of that, studies in recent years have identified a laundry list of harms that appear to follow from overuse of screens, especially in children and teenagers. A 2020 meta-analysis of 31 studies found that more screen time was associated with worse sleep in children under 3. Similarly, a 2023 review looked at 50 studies of teenagers and reported that most of them discovered associations between screen use and poor mental health, especially in girls.

Several lines of evidence point to harm specifically from social media. A 2020 study randomly assigned some teenagers to get fewer

Techno-panics of the past

Throughout history, new communication technologies have caused concerns that sometimes escalated into panic. More than 2000 years ago, the ancient Greek philosopher Socrates worried that the widespread use of written texts would harm the learning of students.

Fast-forward to the mid-1800s, when a boom in the production of newspapers, magazines and often-sensationalist books induced a moral panic about people (mostly women) reading too much and neglecting their children. "There's always been a paternalistic and misogynistic element to these sorts of panics," says Pete Etchells at Bath Spa University, UK.

In the 20th century, television and radio were often seen as the problem – there were concerns in the 1940s that US children were hooked on radio and movie crime dramas. In the 1990s, the internet became more of a focus, with worries about internet addiction and violent video games causing violent behaviour in real life.

The current fears about the impact of screen time and social media on children look distinctly similar to these previous panics. However, we can't dismiss them solely on the grounds that people have previously worried over nothing. "There's this line at the minute which is: 'Is this just another moral panic?'" says Etchells. "It's a completely unanswerable question, because you don't know if you're in a moral panic when you're in it."

likes on social media. Those teens said they felt more rejected and had negative thoughts about themselves. Those who were being bullied or excluded by their peers were most vulnerable. Likewise, a 2022 study found that Facebook's arrival on US college campuses was associated with worse mental health among students.

"Social comparison is one of the strongest possible mechanisms explaining the possible negative effects of social media," says Silje Steinsbekk at the Norwegian University of Science and Technology in Trondheim. "'Everyone has to look so perfect and have perfect lives, that makes me feel miserable.'"

To investigate further, paediatrician Jason Nagata at the University of California, San Francisco, has published several studies looking at associations between screen time and poor health outcomes. Using data from studies that track children over several years, Nagata and his colleagues have spotted some alarming associations. One study found that screen time among 11 to 18-year-olds was linked with a greater likelihood of obesity and diabetes 24 years later. Likewise, more screen time at ages 9 and 10, including watching videos and playing video games, was associated with higher odds of obsessive compulsive disorder two years later – and with a greater likelihood of suicidal behaviours.

Small wonder that many parents and policy-makers are clamouring for stronger rules on screen time, smartphones and social media. The UK parliamentary report from May recommends tighter controls on the sale of smartphones to children under 16, strict bans on mobile phones in schools and more guidance for parents. In 2023, the US surgeon general, Vivek Murthy, recommended that governments "further limit access – in ways that minimize the risk of harm – to social media for all children", and this month he called for cigarette packet-style warnings on social media platforms about the "significant mental health harms for adolescents". UK broadcasting regulator Ofcom has also threatened to ban under-18s from all social media.

The trouble is, though, when you take a closer look at the evidence of harms from screen time, it isn't as strong as it might seem.

Guilty by association

For starters, the vast majority of studies into screen time, smartphones and social media just look for associations. Is more screen time associated, on a statistical level, with a certain harm? This means they can tell us whether the two are correlated, but they can't say whether the screen time is actually causing the harm.

People are often asked to self-report screen time, which is unreliable – particularly if you want to distinguish between types of screen time. This is exemplified by a 2021 review of 33 studies examining whether screen time causes short-sightedness, or myopia. ›

Still on screens

Here's a question many have pondered: has the digital revolution made us more or less sedentary? A 2022 analysis found that, globally, physical activity levels in 11 to 17-year-olds has remained relatively stable since 2010, with around 80 per cent failing to do the recommended amount of activity. The study's authors concluded that increased access to digital media may not be a key driver of this inactivity. Instead, it may simply be replacing other forms of sedentary behaviour, such as reading books and magazines or watching TV.

On the face of it, more screen time was associated with a higher risk of myopia and with more severe myopia. However, none of the studies used a reliable measure of screen time, and seven didn't even objectively measure myopia. The researchers therefore concluded that the findings should be considered cautiously. Another example of this confusion is the debate over screens and sedentary behaviour (see "Still on screens", above right).

In general, when researchers have conducted meta-analyses into the effects of screen time, and especially when they have placed more weight on better-conducted studies, the evidence for harms has both shrunk and become highly nuanced.

One of the best known of these studies is from 2019, when Orben and Andrew Przybylski at the University of Oxford performed a meta-analysis of studies of adolescent well-being, including over 355,000 young people aged 12 to 18 from the US and UK. This found that digital technology use explained at most 0.4 per cent of variation in well-being – far too small an effect to warrant policy changes, they argued.

Yet in this fraught area, the same data can be interpreted in different ways by different researchers. When Twenge, Haidt and others carried out their own analysis of this same data in 2020 – this time separating out social media use rather than just total screen time, plus gender – they concluded that "heavy use of social media is consistently associated with negative mental health outcomes, at non-trivial levels, especially for girls".

More recently, however, meta-analyses suggest adolescent social media use is only weakly linked to depression and anxiety. A 2022 umbrella review combined several dozen previous reviews and meta-analyses, finding that most of them described the evidence of links with mental health effects as "weak" and "inconsistent". A similar exercise in 2023 found a mixed picture. For instance, screen use during childhood was associated with reduced literacy – unless parents watched with their children, in which case it was associated with improved literacy.

Regardless, this doesn't mean the risk is zero. For young people who are already susceptible, some online content can be dangerous. "A specific type of content for a really vulnerable individual at a very specific point in time when they're going through crisis can have harmful consequences," says Orben. But for those who aren't especially vulnerable, the risks are low, says Steinsbekk. "If you're happy, you're good at school, you have a lot of friends, [a] stable family life, it's not very likely that social media will ruin your mental health."

The reality, say researchers, is that simply totting up hours of screen time isn't very informative. "Screen time is a meaningless concept," says Pete Etchells at Bath Spa University in the UK, author of *Unlocked*. "It's a completely useless thing because it could mean literally anything." Yet this is all most studies do. A 2021 review looked at 622 studies of screen time in children up to the age of 6, finding that 60 per cent just assessed the duration of daily screen time. Fewer than 20 per cent reported what the kids were looking at or if parents were also watching, and only 11 per cent gave information on the reliability of their measures.

Researchers like Etchells and Orben want to drill deeper into the ways people interact with screens and digital technologies to understand which behaviours are beneficial or harmful, and which design features enable healthy behaviours. This research is embryonic. For instance, some researchers have argued we should distinguish between active and passive use of social media. The idea is that actively posting may provide benefits, such as new friendships, but passive consumption can cause psychological harm. However, a preprint

15%

of US teens aged **13 to 17** say they visit YouTube, TikTok and Snapchat almost constantly

SOURCE:WWW.PEWRESEARCH.ORG/INTERNET/2023/12/11/TEENS-SOCIAL-MEDIA-AND-TECHNOLOGY-2023/

paper released in March suggests this is also too simple. The evidence doesn't consistently support active use as being beneficial and passive as being harmful, and the researchers argue that behaviour needs to be broken down in even more granular ways.

One argument that resonates with many people is that photo-sharing apps like Instagram can cause or exacerbate body image problems. If everyone else is posting photos of themselves looking slim, toned and airbrushed to supposed perfection, teenagers may start to feel bad about their own bodies. There is little hard data, says Orben, because "platform-specific evidence is hard to come by". But she says it is plausible that sites with a lot of images of bodies could lead teenagers to make more comparisons and judgements about their own bodies. "I think it's a very valid hypothesis."

Again, though, the devil is in the details. Steinsbekk is co-leader of the Trondheim Early Secure Study, which since 2007 has been tracking 1250 Norwegian people born in 2003 to 2004. The aim is to learn how common mental health conditions are and to look for potential causes. The team found that social media use – including specific behaviours like posting, liking and commenting – in childhood and adolescence doesn't predict subsequent depression or anxiety. In a 2021 study, however, the team found that girls (but not boys) who spent a lot of time interacting with other people's posts on social media developed lower self-esteem about their appearance.

Closer friendships

At the same time, there is also evidence that smartphones and social media offer benefits. Kids can find people online who share their interests, which may not be possible if they live in a small town. LGBTQ+ youngsters may find more acceptance in online communities than at home. "We have evidence of young people saying that phones allow them to do a lot of things they care about, like being connected to other people or getting information," says Orben. In line with this, in a study published in April, Steinsbekk's team found that 10 to 18-year-olds who increased their time on social media also spent more time with their friends offline. "Their friendships get closer," says Steinsbekk. This is the opposite of the common concern that screen time disrupts friendships.

Faced with this complex, rapidly changing picture, what should we do? We do have one test case for strict bans: South Korea. In 2011, the government passed the Youth Protection Revision Act, which blocked under-16s from accessing online games between midnight and 6am. The aim was to ensure teenagers got more sleep. However, a 2017 study found that the law increased average nightly sleep by just 1.5 minutes. It was abolished in 2021. Etchells describes it as a "massive waste of time".

There are other potential approaches to help young people deal with the allure of their digital devices. Orben points out that on many websites and apps, you can scroll endlessly, which encourages users to keep "doomscrolling" down the screen. She suggests this could be limited. Other design features like privacy settings could be made more child-friendly. Etchells wants governments to invest heavily in digital literacy training, for everyone.

A ban on these technologies for under 18s would "curtail young people", says Orben. Instead, we should figure out how to make online spaces safe for them. She says young people have a right to be online, and for that space to provide them with good experiences.

"Young people deserve to be part of the digital landscape," she says. "They deserve to build the skills and be able to experience the online world, because it's a key part of what our world now is."

This will require governments to get to grips with the big tech companies. "The power in this network often lies with the companies," says Orben. "I think we should really push for companies to be held to account."

"I'm optimistic about the future and the ways we can harness the technology," says Drouin. "We just need to be really purposeful about the way we're doing it."

In the meantime, what's a parent to do? Here, at least, there is some clear evidence. The key thing is to keep the lines of communication open with your kids, especially when they reach their teenage years and start to become more independent. Think about expectations and boundaries, and have conversations with them about what sort of tech use is appropriate, says Etchells. For instance, suppose your 6-year-old asks for a smartphone. You might well say "no", but don't make them feel bad for asking. Instead, ask them what they want it for, and see if you can find other ways for them to meet those needs and desires. The aim is to set some boundaries while also respecting your child's autonomy.

A 2019 study of 1000 British teenagers found that those whose parents took such an "autonomy-supportive" approach to technology were more likely to believe that their parents trusted them and were less likely to want to disobey, compared with teens whose parents took a more controlling or punitive approach. This respectful approach may make it more likely that your child will tell you if they have a problem online, so you can help them sort it out before it escalates. There is also some evidence that encouraging autonomous behaviour can help teens develop a healthy relationship with social media.

So instead of yelling "get off your phone!", try asking your child what they found on it today. ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for other countries.

Michael Marshall is a science writer based in Devon, UK, and author of *The Genesis Quest*

Rise of the teratribe

Tribalism can result in prejudice, hatred and war. Yet humanity's survival may depend on us becoming a tribe of billions, argues anthropologist **Harvey Whitehouse**

DMYTRO VARAVIN/GETTY IMAGES

IMAGINE yourself in deep space, circling Earth at around 28,000 kilometres per hour. Peering through the window of the International Space Station, you gasp as the sun rises beyond the curved horizon of the planet, like a diamond ring refracting light in all directions. Viewing the world from afar is awe-inspiring, as I discovered when I experienced this as part of a virtual-reality simulation. But it also makes you realise how isolated and vulnerable we are.

Humans are the only species capable of seeing our home from this unique vantage point in space or imagining how it came to be this way. We have always asked big questions about the origins of our world and our place in it. However, that place has changed dramatically over time. Over the past 10,000 years, people have gone from living in small groups of familiars to nations of strangers numbering millions. Tribalism, one of our most powerful evolved psychological biases, has contributed to this expansion. Now, however, it has led humanity to a cliff edge.

Along with our global dominance, we have created a disturbing range of global threats, from climate breakdown and pandemics to famine, war and nuclear annihilation. It may sound contrarian, but I believe that more tribalism would help us meet these challenges. This propensity, although responsible for some of the cruelest acts in human history, has also motivated tremendous feats of cooperation. The need for that is now greater than ever. We require a global tribe of billions – a teratribe. And research by myself and others can help us achieve it.

For most of prehistory, our ancestors lived in small foraging bands composed of individuals who generally recognised each other, knew something about one another's characters and personal histories, and could say who was related to whom. Around 10,000 years ago, the first farmers began to settle down to cultivate crops and domesticate animals. As they did so, human settlements grew dramatically in size and density. By around 7000 years ago, some people were living in kilotribes: elaborate political systems subsidised by agricultural surpluses in which thousands of individuals established ways of cooperating even with relative strangers.

Eventually, the most powerful civilisations grew larger still by invading or absorbing their neighbours, so that by around 4500 years ago, there were some megatribes: societies numbering a million or more. Today, our tribal instincts are the basis of nation-states – but they tend not to extend to the feeling that we belong to a single tribe of humanity.

As an anthropologist, I have spent my working life studying human social groups and trying to understand the evolutionary forces that have shaped our world. This has taken me to archaeological sites, child psychology labs, tribal initiations and war zones in regions as diverse as Europe, Asia, Africa, South America and Oceania. It has also led me to co-establish a vast database of human societies stretching back thousands of years, which we have named Seshat after the Egyptian goddess of writing and record keeping. The insights my colleagues and I have gained through psychological experiments, fieldwork, surveys and mathematical modelling combine to provide a history of humanity unlike any other, as I recount in my new book *Inheritance: The evolutionary origins of the modern world*.

United by warfare

This new science of the social allows us to test competing hypotheses about the evolution of human civilisations more systematically than ever before. For instance, thanks to Seshat, we have shown that moralising religions – those with gods that take a strong interest in right and wrong – emerged with the first multi-ethnic empires, setting limits on the powers of elites and extending the rule of law to all. Statistical analysis of the database has also confirmed that agriculture was one of the most powerful drivers of the rise of larger and more complex societies. But, much to my dismay, it has revealed a second and far deadlier driver of sociopolitical evolution: warfare. Tribalism, the psychological bias that enabled our ancestors to stand united in small warrior groups and hunting parties, has been harnessed to foment interstate conflicts and forms of modern warfare capable of engulfing the entire planet.

Studies in the lab and field can help us understand how tribalism emerges. They reveal that when people feel they share very personally affecting experiences – especially of suffering – with others, their individual and group identities can become bonded together. Psychologists call this visceral sense of oneness with the group "identity fusion". It is one of the most powerful forms of group bonding known to science, and the bedrock of tribalism.

Identity fusion, based on shared experiences, is nowadays being scaled up ever more effectively through forms of immersive media reporting about catastrophic events such as wars, along with their human ›

consequences. Salacious news sells and advertisers exploit this, creating a vicious circle. In its most destructive manifestations, this process has driven increasingly potent forms of transnational radicalisation and terrorist violence. It helps explain not only why soldiers lay down their lives for each other on the battlefield, but also why terrorists strap bombs to themselves. However, if humanity could achieve such intense social cohesion on a grand scale, this could also be harnessed to address global problems in more peaceful ways, from conserving Earth's resources and managing conflict more effectively to reforming our economies and reducing inequality.

I feel your pain

Consider the story of Cecil – a wild lion in Zimbabwe who, in 2015, was shot by a US trophy hunter using a bow and arrow. Reports of the killing went viral almost immediately, causing an outpouring of grief and anger around the world. It so happened that lion conservationists at the University of Oxford, where I am based, were tracking Cecil. Thousands of people jammed their phone lines wanting to know what they could do to support the group's efforts to protect big cats from being hunted illegally. So, my colleagues and I took the opportunity to explore the psychology of these would-be charitable donors. Our large survey uncovered surprisingly high levels of identity fusion with Cecil the lion, rooted in feelings of shared suffering.

This was the first time anyone had shown that people can bond in this way with an entirely different species. But perhaps the most remarkable thing about our Cecil study isn't that fusion can cross the species barrier, but that it can be based on perceptions of shared experiences occurring thousands of miles away and affecting individuals one will never actually encounter in the flesh. If the death of a lion can do that, it suggests that human experiences shared by people around the globe can too.

You may counter that humanity can't unite unless faced with a common enemy, such as an extraterrestrial army. When I raise the prospect of identity fusion across humanity at large with my students, the conversation usually turns to Martian invaders or another sci-fi fantasy. However, the science doesn't back this up. Although some forms of tribalism entail a competitive attitude towards other groups, competition isn't required to achieve identity fusion. This suggests it is possible to be fused with all other humans – potentially even all forms of life – without feelings of rivalry, fear or hatred towards out-groups.

Evidence for this comes from research I have been carrying out with Lukas Reinhardt at the University of Oxford's Centre for the Study of Social Cohesion, where I am director. Our first study was of mothers. Giving birth can be a

"Social cohesion on a grand scale could help us address global problems in peaceful ways"

IVOR PRICKETT/PANOS PICTURES

A form of bonding called identity fusion may help explain why soldiers will die for each other

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truly life-changing experience, and previous research had shown that sharing this self-defining experience can lead to identity fusion. To explore how far this might extend, we ran an online study with 481 US mothers. We found that these women were more fused with and more willing to allocate money to women all around the world if they shared motherhood experiences with them.

Sharing life-changing experiences is one way of fusing people to each other. The other main way is to make them feel like family. When we believe that we share some underlying biological essence with other members of a group, it can bind our personal and group identities together. Throughout the world and stretching back into prehistory, people have recognised the importance of kinship – relationships based on shared essences (often construed as having the same blood or bones or other physical characteristics) inherited from parents and passed down through the generations. Common ancestry is the basis for some of the world's most cohesive communities, including families, clans and ethnic groups. It is also often hijacked by nationalists when they portray their country as a motherland or the great leader as a father figure. If entire nations can feel like family, then why not humanity at large? This was the question Reinhardt and I decided to focus on in our follow-up study.

Global family reunion

To do so, we ran a survey that measured changes in identity fusion among US citizens before and after watching a TED talk by best-selling author A. J. Jacobs. In it, he explains how all people alive today are descended from the same ancestors and therefore we are all members of one giant family. He concludes by inviting everyone to a global family reunion in New York – a vast party intended to bring us all together to celebrate. As predicted, we found that watching the video increased people's fusion with humanity at large. But we also learned that this didn't diminish their feelings of fusion with their compatriots or their extended family – in fact, quite the opposite. Watching the talk increased fusion at all three levels. Even more remarkably, it caused Democrats to become more fused with Republicans and vice versa, bringing these polarised political coalitions into closer alignment and making supporters of the two parties more generous towards each other in a money allocation game.

SUSAN WINTERS COOK/GETTY IMAGES

What's the secret of leaders able to unite opposing factions?

These studies point to the power of identity fusion to heal divisions between rival groups. Whether the same approach could work in more extreme conditions – when rival groups are killing each other, for example – is another matter. This is what Reinhardt and I wanted to find out next.

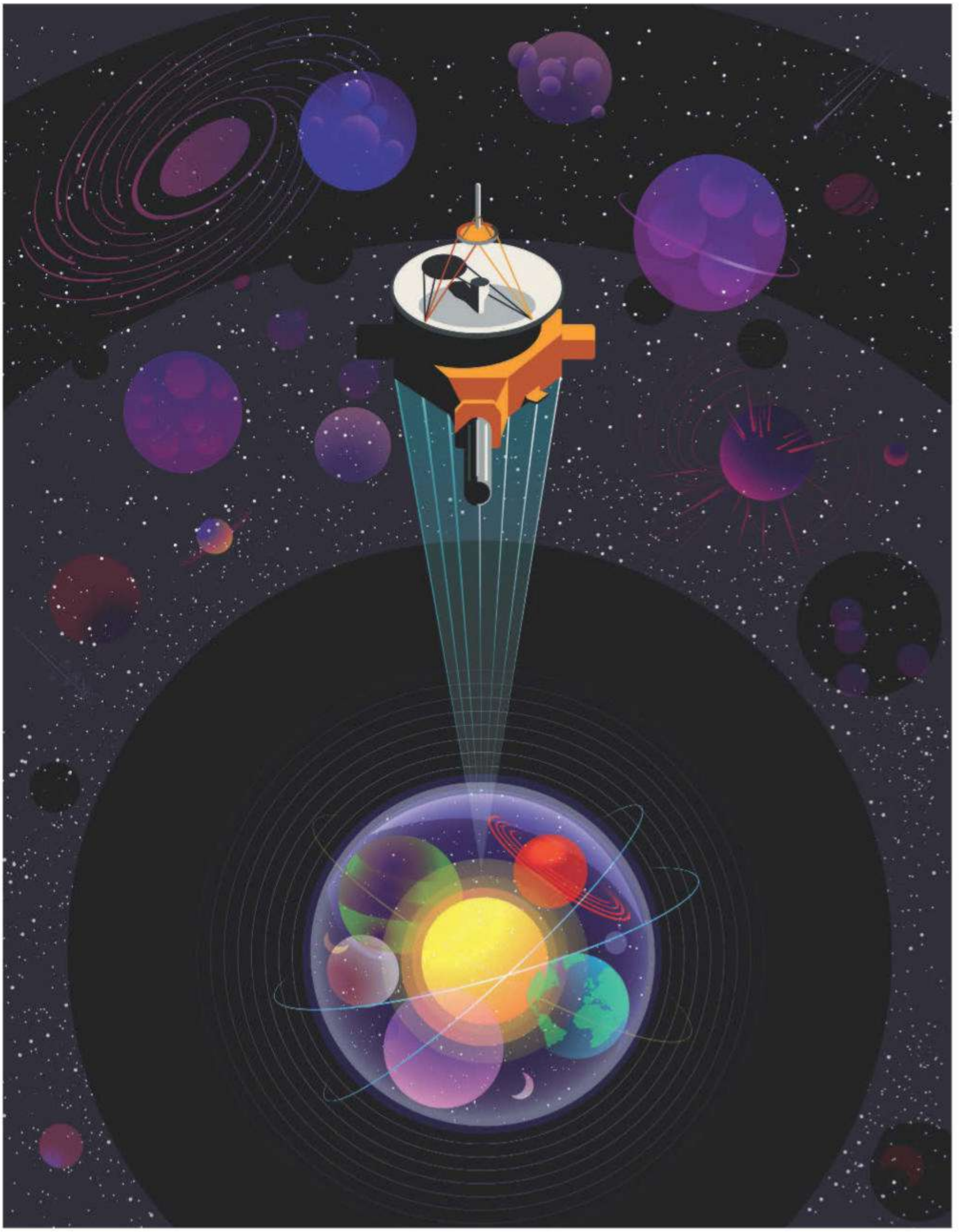
Soon after the start of the war between Hamas and Israel in October 2023, veteran British peace campaigner John Alderdice made a speech in the UK's House of Lords, and he agreed that I could rewrite it so as to emphasise feelings of shared suffering on both sides of the conflict. We then filmed him making the revised speech and showed this to Muslim and Jewish people in the US who aligned with the people of Gaza and Israel respectively. As we had hoped, watching the video significantly increased fusion with the opposing side. Our results, which aren't yet published, also showed that people became more trusting of the other group and more open to friendship with them.

All this suggests that the idea of a teratribe isn't pie in the sky. But if we are to mature into a global tribe, capable of solving global problems, we will also need leaders capable of crossing existing tribal divisions. Such barrier-crossing leaders already exist. Nelson Mandela was a famous example, but there are many lesser-known leaders who work tirelessly to bridge the divisions between their own group and others who oppose or oppress them. In a recent study, my colleagues and I ran a survey with 60 leaders from African American, British Muslim and Irish Traveller communities. Just over half of them were barrier crossers and the rest weren't – we called them barrier bound. Our goal was to figure out how they differed. You might suspect that what distinguishes barrier crossers is a personal quality such as empathy. That isn't what we found.

Once again, this study demonstrated the importance of identity fusion. The most important attribute of barrier-crossing leaders, we found, was a willingness to recognise that personally defining experiences of suffering are shared with people in other groups. Barrier-bound leaders cared about shared suffering too, but they tended to view it more in terms of the grievances of their own tribe, focusing on histories of injustice, which serves to deepen divisions between groups. We also found, unsurprisingly, that barrier crossers had a greater level of identity fusion with the "enemy". In addition, when talking about members of both their own group and other groups, they used the language of family to emphasise intense bonds. This is the kind of leadership we will need if we are to overcome the socially corrosive impacts of polarisation and intergroup conflict that bedevil so many societies today.

No doubt, humanity will always be subdivided into innumerable groups with distinct cultures, languages, dialects and social norms. No doubt, individuals will always affiliate with multiple tribes at different levels. But perhaps we are at last entering a stage in our evolutionary history when we can all pull together if we need to. In the past 10,000 years, our species has made a series of transitions, each increasing the size of groups to which we affiliate. Now, we could be on the cusp of another transition that will see us become fused into a single entity: a global teratribe. To take this leap, we will need to harness our evolved psychology for identity fusion in ways that are grounded in science and address our shared moral concerns and collective interests. It won't be easy, but our ability to stave off an apocalyptic future may depend on it. ▮

Harvey Whitehouse is an anthropologist at the University of Oxford. His new book, *Inheritance: The evolutionary origins of the modern world*, is out now



PETER GREENWOOD

Pushing the boundaries

A plucky space probe could be about to redraw the frontiers of our solar system, finds **Becca Caddy**

NASA's New Horizons spacecraft is hurtling out of the solar system at an incredible speed. It is currently about 8 billion kilometres from the sun, and by the time you finish reading this story, it will have sped thousands of kilometres further into the frigid gloom. It is lonely out there. Even the giant planet Jupiter is but a tiny speck.

New Horizons is mainly known for giving us our first proper look at the dwarf planet Pluto in 2015. Until then, we had only seen it as a blurry smudge. It has also taught us much about the solar system's outer reaches and the small, frozen worlds that float there. "It's really been an Alice in Wonderland kind of story," says Alan Stern, the principal investigator of the mission. "It's been dreamlike and we've discovered wonderful things."

However, the dream isn't over yet because New Horizons may be poised for a surprise final act. In early 2024, one of its detectors recorded an unexpected uptick in the amount of dust it was encountering. Since that material could have been created in collisions between rock fragments, astronomers now wonder if there are many objects beyond the rubble-strewn Kuiper belt often considered the edge of the solar system. If so, our system's boundaries will need to be redrawn and our models of how it formed thrown into doubt.

Stern and his colleagues are obviously keen to take advantage of their probe's unique position to learn more about this unexplored wilderness while they still can. "It's an ongoing detective story," he says.

We have known of the Kuiper belt , a vast doughnut-shaped region teeming with cold rocks and icy bodies, for decades. Its nearest edge is just past Neptune's orbit, at about 30 times the distance from the sun to the Earth, or 30 astronomical units (AU). We assumed the farthest edge of the belt was at about 50 AU.

Perhaps its most famous inhabitant is the dwarf planet Pluto. "When I was a kid, there were nine planets and Pluto was one of them," says Carly Howett at the University of Oxford. But we knew very little about what it looked like. "Every time you looked in a book about space, [Pluto] was just a fuzzy photo. No one knew anything."

New Horizons launched in 2006, the same year that Pluto was downgraded by the International Astronomical Union to a dwarf planet. When the craft flew close by this world nine years later, our impression of it was transformed. It went from an indiscernible smudge to a fascinating place with an atmosphere and signs of volcanic activity.

The mission revealed mountains and plains, and gave us a close look at its incredible moons, such as Charon with its complex surface of canyons. "To be on the team that finally brought Pluto into focus was just astounding," says Howett, who worked on one of the mission's imaging instruments.

But the voyage of discovery didn't end there. Before the spacecraft had even reached Pluto, the New Horizons team had set its sights on finding another target to study. We are aware that there are plenty of icy bodies known as Kuiper belt objects (KBOs) out there (see "Far-flung worlds", p42). But ground-based telescopes couldn't find any within the spacecraft's reach. For a while, it seemed as though there would be no plausible candidates to explore. Then the Hubble Space Telescope took over the search and in August 2015, a target was finally chosen. In January 2019, New Horizons flew past the asteroid of choice, a strange rock about 35 km long named Arrokoth.

The aim of the flyby was to learn more about its composition and surface, to gain some clues to how it may have formed. Arrokoth is a contact binary, meaning it consists of a pair of lobes stuck together, a bit like the sections that make up a snowman.

Not only did we get a better look at Arrokoth, but, coupled with observations that many other objects are binaries, it taught us about the early solar system's building processes. Astronomers had thought that planetesimals – large rocky bodies on their way to becoming planets – grew through high-speed collisions. But Arrokoth's binary nature, two parts that ›

must have come together at a fairly slow speed, showed it was probably a gentler merging process instead. "The discovery that many of these objects in the Kuiper belt are binaries has completely rewritten our understanding of how the seeds of planets, the so-called planetesimals, are formed," says Stern.

The original reasoning behind the fast collisions idea hinges on a description of the evolution of the solar system known as the Nice model. Named after the French city where it was developed, this proposes that the giant planets started out much closer together before migrating to their current positions. These planetary movements would have stirred up the solar system, sending debris zipping around.

But the gentle formation of Arrokoth, along with the unexpectedly stable orbits of many KBOs, suggests Neptune's migration was less disruptive than the Nice framework predicts. The model is valuable for understanding some parts of the solar system's evolution, says Stern, but the insights from New Horizons mean it may need some adjustments.

Mysterious dust

New Horizons gathered such a swathe of data about Arrokoth that it is still being sent back from the spacecraft to Earth for analysis, and it continues to lead to new discoveries. But there were no plans to study any more KBOs up close. The Arrokoth flyby was meant to be the probe's swansong.

Since it left that location, New Horizons has been travelling in hibernation mode, with most of its instruments switched off. It has traversed the Kuiper belt and is encountering new territory, almost 60 AU away from us. Only NASA's Pioneer and twin Voyager spacecraft have ventured further, but their trajectories took them out of the plane the Kuiper belt sits in, whereas New Horizons stayed within it.

The only instrument that remains switched on, a dust detector, has recently picked up something strange. Between 55 and 60 AU, it started to spot more of this material than expected. This is an important indication that there are larger bodies out there that might be smashing together. The presence of all that dust suggested the Kuiper belt may be bigger than we thought.

To better understand what is going on, the New Horizons researchers used a ground-based observatory, the Subaru Telescope in Hawaii, to look at the region beyond the Kuiper belt. Their results, presented at a conference in March 2023, show a surprising number of very distant objects beyond the suspected outer edge of the belt.

"We expected to encounter the Kuiper cliff, where the density of objects drops off sharply," says Anne Verbiscer at the University of Virginia, who is co-investigator of the New Horizons mission. Instead, they found this measure dropped between 50 and 60 AU, but beyond that there were far more objects than expected. Verbiscer says this means there could be a second Kuiper belt.

If that is the case, it would be an enormous discovery. "It would make us rethink many of the properties we see today in the trans-Neptunian region and in the formation of our solar system," says Pedro Bernardinelli at the University of Washington in Seattle. For example, he says, we explain the position of the edge of the Kuiper belt with the hypothesis that another star and our sun had a close encounter in their youth that wiped out any objects beyond that distance. If the Kuiper belt doesn't end there, perhaps that never happened.

While Bernardinelli is excited about the prospect of a second Kuiper belt, he urges caution. The Subaru Telescope results have yet to be peer reviewed – and other studies of the region beyond 60 AU with other ground-based telescopes have come up short. As well as confirmation of the initial results, we would need more detail on the orbits of these objects beyond 60 AU to say whether they are just part of the same Kuiper belt we know of or if they form a second one.

One possible explanation is that the Kuiper belt "just happens to be more extended in the direction New Horizons is flying", says Stern. "Or it could be that others missed it." However, he points out that other studies published in the past 10 years also found evidence in agreement with his team's results.

Whether there really is a second Kuiper belt comes down to the way the objects that populate it move around the sun. When the New Horizons researchers began mapping the Kuiper belt, they discovered significant variations in the distribution and stability of KBOs. Some have what are known as non-resonant orbits, meaning they do their own thing, without being subject to the gravitational influence of nearby Neptune. From this, astronomers can deduce that these KBOs formed where they are right now.

But data from New Horizons has revealed that many more KBOs than expected are in orbital resonance with Neptune. This means that these KBOs precisely line up with Neptune at regular intervals, a bit like the minute and

Far-flung worlds

The New Horizons spacecraft has changed our understanding of the Kuiper belt and the outer reaches of the solar system (see main story). "One of the first real surprises of New Horizons was that very large objects [in this region], like Pluto, are abundant," says Alan Stern, principal investigator of the mission. "It could have been Pluto was an oddball, but it was just brighter and more easily discovered."

There are plenty of strange objects within the icy Kuiper belt. Notable among these are Makemake, a reddish-brown dwarf planet. Scientists have detected frozen methane and ethane on its surface. There is also Eris, which astronomers believe is one of the largest dwarf planets in our solar system. It has a rocky surface.

Anne Verbiscer, a co-investigator on New Horizons, is particularly interested in the dwarf planet Haumea. It is an oddity in that it is shaped like a rugby ball and rotates every 4 hours. Verbiscer says this rapid rate of tumbling could be because there was an intense collision between Haumea and a larger body.

"We think it might still be spinning from that collision," she says. It also has plenty of satellites to explore. "It's got at least two moons that we know of and a ring system," says Verbiscer. "It's a very, very interesting world."

The New Horizons probe is hurtling out of our solar system

JOE OLMSTED/STSCI

ESO/M. KORNMESSER

Left: An artist's impression of the Kuiper belt. Below: The Vera C. Rubin telescope that will help us discover more Kuiper belt objects like Pluto (also pictured)

hour hands on a clock. For instance, a KBO in a 2:3 resonance with Neptune completes three orbits of the sun for every two orbits Neptune makes. This means the KBO's orbit is fairly stable, largely preventing any collisions. And in this case, astronomers can tell the objects must have formed elsewhere, perhaps in the inner solar system, before being gravitationally tugged outwards and slotting into a synchronised orbit with Neptune. "In its early days, the solar system was rearranging itself," says Stern.

Cliff or canyon?

The New Horizons exploration of the Kuiper belt has already challenged our existing ideas about how the solar system formed, including the Nice model. But discovering objects from a second Kuiper belt would really raise eyebrows.

The exact implications would depend on whether these entities were resonant or not, says Wes Fraser at the Herzberg Institute of Astronomy in Canada. "That detail is important because if distant bodies were entirely resonant, they would be most likely transported bodies, originating from closer regions," he says. If this is the case, it would require a revamp of our models of solar system formation, he says, but not a complete rewrite.

On the other hand, if they were non-resonant, this would be a tremendous discovery. "A disc of material at 70+ AU would make our solar system much more in line with the sizes of some of the other known old debris discs [of other star systems]," says Fraser. "Hence the importance of the discovery."

If we do have two Kuiper belts, it would mean that instead of a Kuiper cliff, the gap between the two belts would form more of a Kuiper canyon. This gap, at about 50 to 60 AU from the sun, would make our solar system much more like other systems than we had thought. This will help to put our system into context. "We don't know the extent to which our solar system is unique," says Stern. And it could teach us about our past. Other, younger star systems often have gaps at around 100 AU, so if ours turns out to have a gap too, says Verbiscer, then studying these younger systems might teach us about the history of our own.

> "There could be a second Kuiper belt. If so, this would be an enormous discovery"

RUBIN OBSERVATORY/NOIRLAB/NSF/AURA/STOCKEBRAND

DOTTED ZEBRA/ALAMY

Why these gaps should exist isn't completely clear. In other planetary systems, gaps in the disc are sometimes taken as a sign of a fledgling planet, hoovering up dust as it orbits. "But those are pretty young stellar systems, not like our current solar system," says Verbiscer. Instead, she suggests the gap in the Kuiper belt, if it does exist, could be influenced by gravitational forces. Such gaps are already known in our solar system. For example, there are "Kirkwood gaps" in the asteroid belt between Mars and Jupiter, caused by asteroids being affected by Jupiter's gravity.

There is plenty more to learn, then. And luckily, New Horizons might get an encore. Towards the end of 2023, NASA extended the mission into the late 2020s, and the team is currently exploring whether there are any KBOs ahead of it that it could conceivably fly past and observe.

"The spacecraft is in perfect health, has power in its nuclear battery and a communication range that could allow it to operate until around 2050," says Stern. Plans are now in place to use upcoming telescopes, such as the Vera C. Rubin Observatory and the Nancy Grace Roman Space Telescope, to discover new KBOs for future flybys.

Although we need to find these new targets before New Horizons goes too far, the longer the wait, the more technology advances. "The machine learning, AI and computing power we now have are growing exponentially," says Howett, stressing that these tools are enabling deeper insights into the Kuiper belt.

Ultimately, the craft's journey is a voyage into the unknown. "The Kuiper belt is a puzzle," says Verbiscer. "We just need to put the pieces together." ▮

Becca Caddy is a freelance writer based in London

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p45

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Is it possible to make a microscopic atomic bomb? p46

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A mysterious case of marine mimicry is afoot p48

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Picturing the lighter side of life p48

Dear David

Feeling anxious

In his evidence-based advice column, **David Robson** has some ideas for a reader worried about his daughters' social anxiety

David Robson is an award-winning science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*

THANK you to everyone who proposed questions for my new evidence-based advice column. This time, I am responding to a reader who is concerned about his daughters' social anxiety. "For one of them, this is so high that she feels unable to ever start a conversation with someone outside of the immediate family," he tells me. How can he help?

It is a major dilemma for many parents. Social anxiety affects adults and children alike, but it seems to be especially problematic in the second decade of life, with the US National Institute of Mental Health estimating that around 11 per cent of adolescent girls and 7 per cent of adolescent boys meet the diagnostic criteria.

Anyone who is struggling should seek the help of a trained professional, who may offer medication or cognitive behavioural therapy (CBT). But there are also some immediate practical steps that you can take to soothe some of the worries.

For many people, the fear of others' rejection is compounded by their own self-criticism. They can beat themselves up for any slightly awkward moment in an interaction. This can lead to excessive rumination after each encounter, thoughts that only lead them to feel greater fear the next time they have to talk to someone.

People who have social anxiety may therefore benefit from practices that encourage greater self-compassion. One first step is to spot the signs that we are descending into this negative thought spiral and to try to question the chain of thoughts. Since we may feel shame at the anxiety itself, which increases our sense of isolation, we can remind ourselves that many people have experienced similar feelings. And we can try to consciously cultivate kind thoughts by expressing concern and forgiveness in a sort of dialogue with ourselves. It might be as simple as thinking "I know you are scared, but you've got this under control" or "it is human to make a social mistake".

MELANIE ACEVEDO/GETTY IMAGES

Self-compassion programmes often involve short meditations that encourage listeners to recognise the "shared humanity" of their painful feelings and to cultivate gentler thoughts towards themselves. You can find some examples in the resources on the left. Crucially, these exercises can be adapted for people of different ages, even the very young. They shouldn't be seen as an alternative to professional help – but they do seem to bolster resilience on many measures of mental health, including social anxiety.

Perhaps the most important thing for our reader's daughters to remember is that social anxiety is treatable. Our brains are perfectly capable of adopting new patterns of thought and behaviour. The way we feel today needn't reflect the way we feel in the future – and recognising this fact can itself be a source of comfort during difficult periods. ▮

Resources

Self-compassion exercises from Kristin Neff at the University of Texas at Austin (rb.gy/fxgk59)

"Four habits to help kids with social anxiety", from the Greater Good Science Center at the University of California, Berkeley (rb.gy/f4e2cp)

Project CARE – a guide to self-compassion for adolescents, created by the Lab for Scalable Mental Health at Northwestern University, Illinois (rb.gy/d9rn3w)

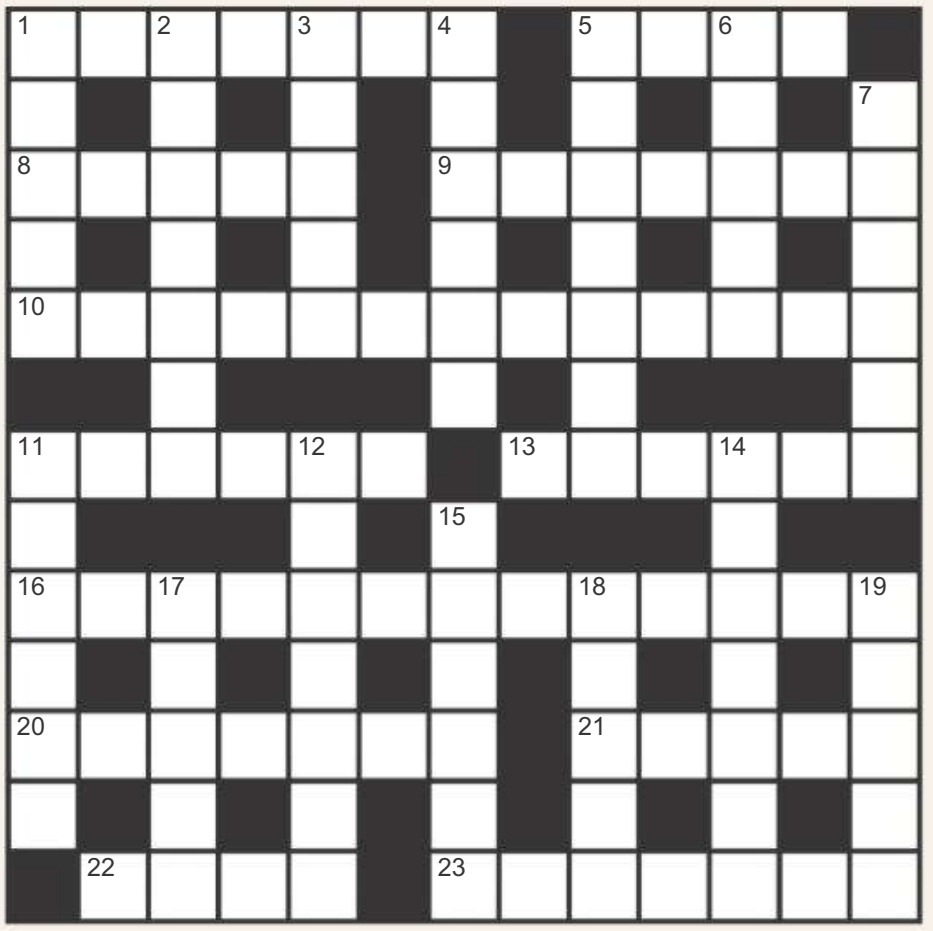
Dear David, an evidence-based advice column, appears monthly. Drop David a line with your social dilemmas at davidrobson.me/contact

These articles are posted each week at newscientist.com/maker

Next week

Stargazing at home

Cryptic crossword #138 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Butter boy's wild garlic (7)
5 Cautious with promotion of article that's wrong (4)
8 Social media nickname employed by vain statistician (5)
9 Supply milk past the deadline, skirting piece of legislation (7)
10 Rogue erecting complicated clicking device (6,7)
11 Chest cold sufferer in conversation (6)
13 Inquires after Flo, dropping round lab containers (6)
16 Reactions of misguided AI system interrupting bacchanals (4,9)
20 Bit of negativity involving timeline bug (7)
21 Put a coat on, heading to glamorous lounge (5)
22 Tight-fitting arms? Return it (4)
23 Calls about stripped down sun shades (7)

DOWN

1 Feeling sorry for general in the wake of destruction (5)
2 Parents fight dog (7)
3 Egg-shaped tank in empty outhouse (5)
4 Genetically engineer snake parasites without adenine (6)
5 Discussed a nasty build-up (7)
6 Get too heated when surrounded by nonsense (5)
7 US engineer fires punk outside castle (6)
11 Paris establishment slightly reduced light brown garment (6)
12 Dodging Tesla, for instance, with a small dent (7)
14 Stew from Greece is almost too formal at a party (7)
15 Unyielding female in need of a clothes brush? (6)
17 Regularly bring home tailless fox in lift (5)
18 Glower when big cat hybrid changes hands (5)
19 Details small targets for bench presser (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #257
set by Bethan Ackerley

1 What name did 17th-century microbiologist Antonie van Leeuwenhoek give to the microbes he observed with his pioneering microscopes?

2 Herbicides that cause the leaves of plants to fall off are known as what?

3 How many vertebrae are there in the human spine, in general?

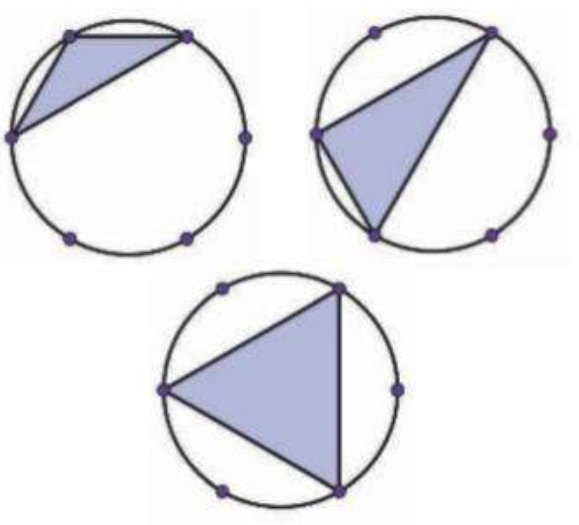
4 In which constellation would you find the Horsehead Nebula?

5 Menthol primarily acts through which channel to elicit a cool sensation?

Answers on page 47

BrainTwister
set by Sam Hartburn
#25 Triangles in circles

If you have six equally spaced points on a circle and join three of them, you can make three different triangles. (Two triangles are counted as the same if one is a mirror image or rotation of the other.)



How many different triangles can you make from seven equally spaced points?

And how many can you create from 12 equally spaced points?

Solution next week

Going nuclear

Is there a minimum size for an atomic bomb? Would it be possible to make a microscopic one that results in a very small explosion?

Simon McLeish
Lechlade, Gloucestershire, UK
Nuclear explosions are different from conventional explosions. A normal explosive substance uses an external detonating trigger, and smaller quantities of explosive cause smaller explosions (from bombs akin to those used in the second world war, which destroyed buildings, to the cap in a toy pistol). A nuclear bomb doesn't work like that – at least, not a fission bomb such as the ones set off in Hiroshima and Nagasaki.

A radioactive substance releases radiation all the time, produced by its inherent atomic instability. In radioactive fission, atoms break apart, causing the emission of radiation. This can cause other atoms to fission, with the release of more particles – like balls on a snooker table when hit by the cue ball. This is a chain reaction, but for small quantities of the radioactive material, it will just fizzle out rather than cause an explosion.

"A microscopic atomic bomb with less than a gram of fissionable material would be impossible to manufacture"

When there is enough of the radioactive material (the "critical mass"), the chain reaction can start to accelerate uncontrollably, and the bomb explodes.

The actual mechanism of an atomic bomb is, in principle, fairly simple: two masses of radioactive material, each less than the critical mass but together larger than it, are forced together very rapidly (using, for instance, a conventional explosive). The chain reaction quickly goes out of control and the bomb explodes.

The critical mass is the minimum possible size at which this happens, and how big that is depends on the radioactive material being used.

The uranium used at Hiroshima in 1945 weighed 64 kilograms, of which only about 1 kilogram fissioned. However, as with any "successful" atomic bomb, it required shielding and a delivery mechanism to keep the person deploying it safe, which ended up making it larger. The overall weight of the device, codenamed Little Boy, was 4400 kilograms, almost 70 times the weight of the uranium.

A smaller atomic bomb requires a less stable radioactive substance, so is more dangerous to build and control. A microscopic one with less than a gram of fissionable material would be impossible to manufacture or control.

Richard Miller
London, UK
Anyone able to give an accurate answer reflecting the state of the art in nuclear weapons design is unlikely to be at liberty to respond, but enough information is in the public domain to put a reasonable upper bound on the size of the smallest possible atomic bomb.

In pursuit of that figure, the W54 warhead developed for the Davy Crockett tactical nuclear weapon was about the size of a suitcase, incorporating 4 kilograms of fissile material and 12 kilograms of conventional explosives.

This is already less than half the quantity of fissile material required to reach the spherical critical mass of pure plutonium (11 kilograms), and only works due to the use of explosive lenses to compress the core and a neutron-reflecting layer of beryllium (or something similar) to amplify the chain reaction once detonated.

Stephen Johnson
Eugene, Oregon, US
All atomic bombs start with a fission reaction, where a neutron causes a nucleus to split, releasing some number of neutrons and an amount of kinetic energy (around 200 megaelectronvolts in the case of uranium-235).

Although this is a lot of energy from a single atom, it doesn't produce any sort of explosion. The explosion we see with nuclear weapons is caused by the splitting of around a trillion trillion atoms in a microsecond.

At this scale, the combined kinetic energy heats the core of the weapon to a temperature hotter than the surface of the sun, which causes massive expansion of the core. This expansion and the subsequent shock wave is what we see as an atomic explosion.

In the late 1950s, the US designed the W54 atomic weapon for use in artillery, small, air-launched missiles and even as a portable backpack explosive. This weapon had a yield as small as the equivalent of around 10 tons of high explosives.

An even smaller weapon could be created by changing the geometry of the core and surrounding it with neutron-reflecting materials. However, no atomic weapon will ever be really small, let alone microscopic.

STOCKPLANETS/GETTY IMAGES

Some animals have disproportionately large feet while growing, so why not us?

This week's new questions

Big foot **The young of many animals grow larger feet before the rest of their body catches up. Why are humans, in this context, so different?** ***Hugo Fair****, London, UK*

On the edge **If we could take a giant step to the furthest point of the universe and look out, what would we see?** ***Steve Pry****, Romulus, Michigan, US*

Shower power

Why, when I first step into a hot shower, do I get a brief shiver down my back?

David Muir
Edinburgh, UK
There are receptors in your skin that detect pain, pressure, vibration, texture, heat and cold.

Want to send us a question or answer?
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Tom Gauld
for New Scientist

SCIENCE CAT
SMASH!
ONCE AGAIN, THE EXPERIMENT CONFIRMED MY HYPOTHESIS, BUT FURTHER RESEARCH IN THIS AREA IS REQUIRED.
I LOVE SCIENCE!

On occasion, however, they can be confused. Your back has fewer receptors per unit area than most parts of your body, so it is more easily befuddled, even if briefly.

Walk backwards into a hot shower and the water hitting your skin can initially feel cold; walk backwards into a cold shower (masochist!) and it can, for a second, seem hot.

You are experiencing a sensation called the paradoxical response to heat, self-explanatory in its name. This transitory perceptual illusion can become problematic with certain neurological conditions, but it is hardly noticed by most of us. The central mechanism is still not entirely understood.

Going naked

Why aren't humans covered in hair like other primates are? (continued)

Paul Seedhouse
Newcastle upon Tyne, UK
In his answer to this question, Anthony Woodward dismisses the idea that hairlessness enabled hominins to hunt down animals on the savannah without overheating, but he makes the mistake of assuming that speed is the only effective hunting strategy available. All successful predators play to their evolutionary advantages, and hairlessness in humans enabled persistence or endurance hunting on the savannah.

"Predators play to their evolutionary advantages, and hairlessness in humans enabled endurance hunting"

David Attenborough suggests that this may be the most ancient human hunting strategy and that it could have been conducted even before weapons were developed. His film of a human running a Kudu antelope to death over 8 hours can be watched on YouTube.

Attenborough suggests that humans have the advantage that they can cool themselves by sweating from their pores and carrying water, and that running on two feet over long enough distances is more efficient than running on four feet.

Woodward notes that cheetahs can run at 110 kilometres per hour, but the downside is their lack of endurance, partly caused by rapid overheating due to their thick coat of hair. Hunts are usually limited to 300-metre sprints, after which cheetahs require up to 30 minutes to recover before eating or moving their prey, which is often stolen by other predators at this point.

It remains to be seen which predator remains around as a species for the longest.

Talia Morris
Cape Tribulation, Queensland, Australia
The answer to this one is simple: we are. Human skin has as many hair follicles per unit area as that of other primates, but because our body hair is much finer, it is less visible. ▮

Answers

Quick quiz #257 *Answers*

1 Animacules
2 Defoliants
3 33
4 Orion
5 TRPM8

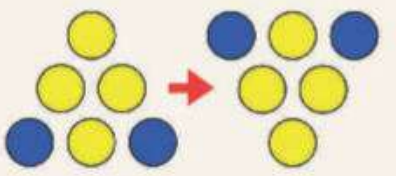
Quick crossword #160 *Answers*

ACROSS 1 Deja vu, **4** Cortisol, **9** Mousse, **10** Smelting, **12** Fade, **13** Meitnerium, **15** Jacquard card, **18** Grasshoppers, **21** Greenfinch, **22** Tier, **24** Nutrient, **25** Loa loa, **26** Lessened, **27** Wrasse

DOWN 1 Dome Fuji, **2** Jaundice, **3** Vast, **5** Osmotic shock, **6** Tiller-rope, **7** Spirit, **8** Legume, **11** Neuroscience, **14** Quarantine, **16** Vesicles, **17** Username, **19** Agonal, **20** Testes, **23** Four

#24 Coin flips *Solution*

A triangle with six coins can be made to point downwards by moving two of the corner coins to the opposite side, for example:



For a triangle with four rows, we need to move the three corner coins to invert the triangle. If we consider triangles of all sizes (starting from a triangle with two rows), the number of coins in each triangle is 3, 6, 10, 15, 21, 28... and the number of coin moves needed to flip each triangle upside down is 1, 2, 3, 5, 7, 9 and so on. The general rule is to divide the number of coins by 3, ignoring any remainder. For larger triangles, instead of moving single coins, you need to move triangles of coins from each corner.

Legless on the shore

Extremities can bring confusion even to trained experts. Joanna Glengarry and Melanie Archer at the Victorian Institute of Forensic Medicine in Australia warn that forensic pathologists and anthropologists "should be prepared to face a variety of presented remains and objects".

Glengarry and Archer present their own firsthand experience – in their words, "a case of what appeared to be a severed foot located on a beach, which examination revealed was a marine animal known as a sea squirt (ascidian)".

Writing in the journal *Forensic Science, Medicine and Pathology*, they give step-by-step details of their adventure. The title of their report? "Marine mimicry is afoot".

Holy ghostwriters

Yes, some people are dismayed when senior department members automatically get co-authorship credit for research done by people of lower status (Feedback, 11 May). But maybe more credit should go to said senior members.

Reader Bob Masta writes in about two doctoral students who asked for his advice after they "had developed a procedure that greatly improved success rates for ridiculously-difficult experiments attempting to record signals from auditory hair cells in the inner ear of guinea pigs... [B]ut the lab's principal investigator and the department head insisted on inclusion as authors... even though they had no knowledge of the work ahead of time".

"I was appalled," writes Masta, "but eventually came around to seeing the wisdom of this. As unknowns in the field, the students might have had a hard time getting published. [Their] credibility in the field would be greatly enhanced by having respected names on the paper. And everyone in research already took it for granted that the lead authors on any paper did the actual work, while the trailing senior authors provided the facilities and usually some consultation."

And, Masta explains, "research labs require grant money to be able to do research and train students. So publications that enhance the status of the senior authors, who have to get those grants, help everyone."

Feedback, unconvinced, feels that credit-grabbing injects rot-from-the-head-down-ness into the system. But if you're going to do it, why not go the whole hog? Share credit with everyone – everyone! – who stands to gain from it. Give co-authorship credit to all higher-level officials (department chair, division head, vice president(s), president, chancellor, corporate board members, emperor, etc.) of the institution that employs the actual researchers.

Feedback suggests that these high-powers, the non-author authors, be known unofficially as "holy ghostwriters".

Twisteddoodles *for New Scientist*

Got a story for Feedback?

Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Wholly ghosted writers

Reader Max Perkins proffers an alternate way to deal with the who-gets-listed-as-an-author question. He writes: "As [a person from a] university department in New South Wales, Australia, I would like to tell Feedback about two postgraduate students at my alma mater who altered their names on the door of their office to read simply 'et al'.

"I think this spoke strongly about the Professor's citation index, and perhaps also as a comment on the use of such as a measure of worth to the university."

Infectious failure

"Everybody tries to not get Covid but, in this study, all 35 volunteers who tried their best to fall ill (with a lot of help from scientists) completely failed." Reader Chittaranjan Andrade sent Feedback this cheerful lament after he read a report in *The Lancet Microbe*.

The team behind said report – Susan Jackson at the University of Oxford and her numerous collaborators – aimed to test the ability of new vaccines to help people who, long after receiving early versions of a vaccine, got infected by new variants of the coronavirus.

The researchers had trouble completing the project's first big step: to infect those volunteers. Their write-up explains and complains that despite "escalating the inoculum dose to the maximum available... we were unable to induce sustained infection in seropositive individuals".

Covid-19, having knocked the world off kilter for several years, now causes problems even when it fails to cause problems.

Worms on the turn

Not all flatworms have a pleasant taste.

Leigh Winsor reports that the invasive New Guinea flatworm (*Platydemus manokwari*) "has a most unpleasant astringent taste... just as has been noted for other species".

Winsor, a researcher at James Cook University in Australia, published this news as part of his "continuing collaboration with Professor J-L Justine, Museum National d'Histoire Naturelle, Paris, France, and Prof Romain Gastineau , University of Szczecin, Poland, on invasive land planarians in France and in French Territories".

Bad taste can linger. Winsor notes that he did the *Platydemus manokwari* tasting (or "pers. obs.", as he puts it) in 1994. ▮

Marc Abrahams

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